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REPORT ON SURFACE SOIL SAMPLING FOR NATURALLY OCCURRING ASBESTOS GARDEN VALLEY, CALIFORNIA

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EXECUTIVE SUMMARY

In November1998 and September 1999, the California Air Resources Board (ARB) collected ambient air samples in the Garden Valley area and found asbestos concentrations, that might pose a risk to human health. Visual observation by the California Environmental Protection Agency, Department of Toxic Substances Control (DTSC) indicated that there are numerous potential sources of naturally occurring asbestos (NOA) within two miles of Golden Sierra High School that may be responsible for asbestos emissions. NOA in this area is associated with serpentine rock, which is a form of ultramafic rock.

To address this concern, DTSC conducted field sampling within a sixteen square mile area around the Golden Sierra High School. The investigation of Garden Valley is part of a site discovery project that is funded by a Superfund cooperative agreement between the U.S. Environmental Protection Agency (U.S. EPA) and DTSC. This project was the initial step in collecting information to identify potential sources of NOA that might be released to the air within the Garden Valley Site Discovery Area (GVSDA). Potential NOA sources identified include:

- Two serpentine rock quarries (one active and one inactive),
- Numerous unpaved roads, unpaved driveways,
- Road cuts,
- Road shoulders,
- School bus stops,

North-south trending natural outcroppings of serpentine rock border the GVSDA to the east and west. As a first step, this investigation focused on Bear Creek Quarry, Garden Valley Aggregate, selected private unpaved roads, selected school bus stops and one road cut located on Marshall Road.

DTSC collected soil samples in August and September of 2000. Private road samples were collected with property owner’s consent. Inspection Warrants were obtained to gain access and collect samples at Bear Creek Quarry and Garden Valley Aggregates. DTSC collected a total of 137 samples within the GVSDA.

DTSC contracted with ALS Chemex, Inc. (Chemex) to prepare the samples for analysis. Preparations completed by Chemex included determination of moisture content, size fractionation of samples and Method CARB 435 sample preparation. Following preparation activities, the samples were shipped to the RJ Lee Group, Inc. (RJ Lee) of San Leandro, California. DTSC contracted with RJ Lee to analyze these samples using Polarized Light Microscopy (PLM) following Method CARB 435 procedures. In addition, the U.S. EPA contracted with Forensic Analytical of Hayward, California, to analyze 106 of the samples by Transmission Electron Microscopy (TEM) following EPA Method 600/R-93/116 procedures. DTSC and U.S. EPA included TEM analysis in the project to provide clearer resolution of asbestos concentrations near or below the detection limit of PLM.

PLM data produced by RJ Lee and TEM data produced by Forensic Analytical were inconsistent among the data sets and were generally lower than asbestos concentrations from samples collected in the Garden Valley area during the late 1980's by the U.S. EPA and ARB. To investigate these discrepancies, additional analyses were done by Forensic Analytical using PLM Method CARB 435 procedures. In addition, six samples were analyzed by x-ray diffraction (XRD) to determine the sample mineralogy. Analysis of the PLM data produced by RJ Lee and Forensic Analytical indicated significant discrepancies between the results reported by both laboratories. Furthermore, significant discrepancies existed between PLM and TEM results reported by Forensic Analytical for samples undergoing both analyses. XRD analysis confirmed the predominate mineral type as lizardite, but it was unable to quantify the chrysotile concentration.

Because of the conflicting data produced by RJ Lee and Forensic Analytical, DTSC and U.S. EPA concluded that all the samples needed to be rerun by an additional laboratory. EMSL Analytical (EMSL), Westmont, New Jersey was selected to analyze all samples using PLM following Method CARB 435 procedures and the same 106 samples Forensic Analytical analyzed via TEM following EPA Method 600/R-93/116 procedures. The U.S. EPA submitted the 178 soil samples, previously prepared by Chemex, to EMSL for PLM analysis. One sample, GV-90 (-200), was used for U.S. EPA's audit of RJ Lee and not available for analysis by EMSL. Results of EMSL's PLM and TEM analyses indicated the following asbestos concentration ranges:

Sample Location	Number of Samples	PLM results[1]	TEM results[2]
Bear Creek Quarry	29	< 0.25% to 15%.	0.67% to 7.3% chrysotile
Garden Valley Aggregates	35	< 0.25% to 4.5%	0.17% to 2.7% chrysotile, <0.1% to 1.7% tremolite (four samples), <0.1% anthophyllite (two samples).
Unpaved Roads	52	Non-detect to 4.0%.	<0.1% to 7.7% chrysotile
School Bus Stops	13	Non-detect to 2.8%.	<0.1% to 5.9% chrysotile
Cut on Marshall Road	8	<0.25% to 1%.	<0.1% to 0.61% chrysotile, <0.1% to 0.16% actinolite and tremolite (one sample), <0.1% actinolite (one sample)

[1] PLM data is expressed as percent by number based on number of asbestos fibers counted divided by 400 which is the total number of particles counted per the CARB 435 Method.
[2] TEM data is expressed as percent by weight based on fiber volume and density as specified in the USEPA method 600/R-93/116

The mean concentration of all the PLM samples was 1.1%. Chrysotile was the only asbestos type found during the PLM analysis. The TEM data reported by EMSL had a mean concentration of 2.1% asbestos. The majority of the asbestos detected was chrysotile, although trace amounts of actinolite, tremolite, and anthophyllite were detected in several samples.

The EMSL data indicates that the serpentine found throughout the GVSDA contains low levels of asbestos. Asbestos concentrations in Bear Creek Quarry samples were slightly higher than concentrations of asbestos in other areas evaluated.

The GVSDA soil sample results are significantly lower than the historic soil sample results reported in the late 1980s by ARB and U.S. EPA. The possible explanations for these differences include:

1) The 1990 Air Toxic Control Measure (ATCM), which required surface application of serpentine rock to contain no more than five percent asbestos, so any re-surfacing activities subsequent to the ATCM would be expected to contain less than five percent asbestos;

2) Quarry owners may have been more diligent in avoiding serpentine rock with higher concentrations of asbestos; and

3) Current mining operations may be occurring in geologic formations within the quarry which have different mineralogical properties from that of the historically mined serpentine.

4) Difference in sampling & analytical methods.

While the both quarries identified in the GVSDA contain asbestos, they do not appear to be major contributors to the Garden Valley air emissions for the following reasons:

1) Bear Creek Quarry is predominately down-wind from the Garden Valley community and is separated by a ridge. In addition, Bear Creek Quarry was observed implementing some dust control measures during mining activities, and is subject to regulatory oversight by the El Dorado County Air Pollution Control District.

2) Garden Valley Aggregates is inactive and largely undisturbed with the exception of infrequent movement of stored heavy equipment and occasional access to the caretaker’s quarters via an unpaved serpentine road.

Based on the EMSL data and the frequency of disturbance, DTSC believes that the unpaved serpentine roads are a major source of airborne asbestos and further studies are warranted to determine the asbestos emissions from selected roads. This data would provide the Garden Valley community information regarding potential exposures.

It is also recommended that private property owners with serpentine roads resurface roadways on their properties with non-asbestos containing materials.

Some of the school bus stops contain serpentine rock, but as a whole do not appear to be a major contributor to area-wide asbestos emissions. It is reasonable to assume that that school bus stops, which do contain serpentine rock, contribute to proximal asbestos emissions during loading and off-loading activities. Approximately two and one-half years ago the Black Oak Mine School District opted to discontinue the use of serpentine aggregate to repair potholes at school bus stops. Bus stops are currently resurfaced with limestone on an “as needed” basis. DTSC recommends that remaining bus stops surfaced with serpentine rock be resurfaced with limestone or other suitable material.

1.0 INTRODUCTION

In November 1998 and September 1999, the California Air Resources Board (ARB) collected samples from air monitoring stations located at the Golden Sierra High School, Garden Valley Park, and in close proximity to the Garden Valley Aggregates. The sample results showed asbestos concentrations that could pose a risk to human health. Visual observations by DTSC indicated that there were numerous potential sources of NOA within two miles of Golden Sierra High School that may be responsible for asbestos emissions. In August and September 2000, DTSC conducted field sampling in Garden Valley as part of a site discovery project funded by U.S. EPA under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). CERCLA is commonly known as Superfund. This project is the first step in collecting information to identify potential sources of NOA that may contribute to airborne asbestos emissions within the GVSDA. This project is considered an initial screening for potential sources of asbestos and not a comprehensive investigation. For the purposes of this document, NOA refers to all mineral forms of asbestos that have been or potentially could be disturbed through human or natural activities. NOA does not include manufactured building or other manufactured products that may contain asbestos. Unless specified, the term “soil” will refer to a heterogeneous mixture of dirt, rock, and/or crushed aggregate. This document also references “children” which refers to all people less than 18 years of age.

The community of Garden Valley is located between two north-south trending serpentine deposits. These deposits contain one active serpentine aggregate quarry (Bear Creek Quarry) and one inactive serpentine quarry (Garden Valley Aggregates). NOA is associated with serpentine and other altered ultramafic rocks. Furthermore, serpentine aggregate has been used in many surfacing applications throughout the GVSDA, e.g., road aggregate.

Currently, neither the U.S. EPA, nor the State of California has established a risk-based action level for asbestos in soil. Action levels for asbestos are based on air concentrations.

The objectives of this sampling effort included collecting soil samples from potentially controllable NOA source locations, determining the asbestos content using PLM and TEM analysis, determine the moisture content of the samples, and determine particle size distribution of selected samples. The information that is gathered from this project will be used to determine what subsequent actions may be appropriate to assess NOA emissions in Garden Valley. For example, DTSC could use NOA soil concentrations as an indication for potential air monitoring locations and further source assessment.

Sources of NOA in the GVSDA investigation included:

- The active Bear Creek Quarry and the inactive Garden Valley Aggregates,
- Selected school bus stops within GVSDA where serpentine aggregate may have been used,
- Selected unpaved roads, and
- Detrital sediment associated with the Marshall Road (adjacent to a large road cut through a serpentine formation).

2.0 BACKGROUND

2.1 Problem Definition

Garden Valley ambient air samples collected by the ARB indicated a health risk from ambient air asbestos exposure may exist. Visual observations by DTSC indicated that there were numerous potential NOA sources that may be responsible for asbestos emissions. DTSC's objective was to identify the most likely major sources of asbestos emissions through the collection and analysis of surface soil samples.

2.2 Health Concerns

Asbestos is a generic term for a group of six naturally occurring, fibrous minerals (asbestos includes actinolite, ammosite, anthophillite, chrysotile, crocidolite and tremolite). Asbestos minerals are created from ultramafic rocks. Ultramafic rocks contain two asbestos bearing groups: serpentine asbestos and amphibole asbestos. Serpentine asbestos, which includes the mineral chrysotile, is a magnesium silicate mineral, possessing relatively long, flexible crystalline fibers that are capable of being woven. Serpentine minerals are usually formed from peridotite by hydrothermal metamorphic processes. Amphibole asbestos, which includes the mineral series tremolite-actinolite, forms shorter crystalline fibers that are substantially more brittle than chrysotile asbestos. Amphiboles, such as the tremolite-actinolite series, are formed principally from metamorphic processes involving ultramafic deposits and are often associated with faulting. While the chrysotile asbestos is often associated with serpentine rock outcrops, amphibole asbestos can also be found in some serpentine formations.

All asbestos minerals are hazardous and when inhaled may cause lung disease and cancer. Health risks are dependent upon human exposure to asbestos fiber. The longer a person is exposed to asbestos and the greater the intensity of exposure, the greater the chances for a health problem. Asbestos-related disease, such as lung cancer, asbestosis, and mesothelioma, may not occur for decades after breathing asbestiform fibers. For mesothelioma cancer, age and time of asbestiform exposure are also factors in increasing risk. For example a ten-year-old child exposed to a prescribed dose of asbestos for a period of 20 years is at higher risk than a 30 year old with the same exposure. Risk assessment for asbestos is based on fiber concentrations in air. No safe level of asbestos has been established for soil.

2.3 Location

GVSDA is located in El Dorado County, California (see Figure 1). The geographic coordinates of the site are approximately 38^{o}51' 15" N latitude and 120^{o} 51'30" W longitude (Township12N, Range10E, Section 5). The GVSDA is located in the foothills of the Sierra Nevada Mountains. The average elevation of the GVSDA is approximately 2,000 feet. DTSC chose the boundary of the GVSDA area as approximately a two-mile radius around the Golden Sierra High School (see Figure 2). The GVSDA is approximately 5 miles east of Coloma.

2.4 Description

The GVSDA is approximately sixteen square miles in area. The discovery project focused on potentially significant sources of NOA that may be controlled, including; two quarries, school bus stops along several roads, unpaved roads, and road cuts. The GVSDA is located within five miles of the South Fork of the American River, which is used extensively for recreational activities during the summer.

Bear Creek Quarry and Garden Valley Aggregates are located within north-south trending serpentinite formations. These quarries are approximately four miles apart. The Bear Creek Quarry parcel is approximately 38 acres with approximately 10 acres directly associated with current mining operations. The inactive Garden Valley Aggregates parcel is approximately 11 acres with approximately 8 acres associated with past mining operations.

Vegetation is varied throughout GVSDA. Vegetation densities vary from abundant forested areas surrounding the Golden Sierra High School to sparse vegetation (manzanita, buck brush, digger pines) in the vicinity of the quarries. The plant types are closely associated with the type of geologic formation beneath it.

Winters are cool and wet and summers are hot and dry. The area is subject to significant winds due, in part, to the thermal effects associated with canyons.

2.5 Regulatory Involvement Within GVSDA

2.5.1 U.S. Environmental Protection Agency

In July 1986, a resident of the Garden Valley Ranch Estates collected a soil sample from a road within the Garden Valley Ranch Estates subdivision and submitted the material to Thermal Analytical/EAL laboratory. The laboratory analyzed the sample by phase-contrast microscopy. Results indicated the presence of chrysotile asbestos ranging in concentration from ten to twenty percent. The resident then contacted the U.S. EPA Emergency Response Unit to inform them of the results. U.S. EPA used the National Emissions Standards for Hazardous Air Pollutants (NESHAP) control level of one percent for asbestos concentration in soil samples as an action level and dispatched a Technical Assistance Team (TAT) to the area to collect further samples.

The TAT collected composite soil samples at various locations along the unpaved roads. Sample results indicated chrysotile asbestos concentrations ranging from two to twenty-five percent. This data along with other factors (e.g., roads located in a residential area) provided U.S. EPA with the rationale to chip seal the serpentine aggregate roads (see Appendix A).

GVSDA is not listed in the Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) database. CERCLIS is the inventory of the U.S. EPA's inventory of potential Superfund sites and ongoing cleanups. The site is not listed in the Resource Conservation and Recovery Information System (RCRIS). RCRIS is an inventory of hazardous waste facilities regulated by the U.S. EPA and the State of California. Currently, U.S. EPA is providing technical and financial assistance for the GVSDA project.

2.5.2 California Air Resources Board

In May 1987 ARB collected samples from the Bear Creek Quarry (and other serpentine quarries) as part of an effort to determine the asbestos content of serpentine rock used as road cover aggregate. There were three objectives of this effort; 1) determine the percent asbestos in the serpentine aggregate used as road cover, 2) conduct sieve analysis and determine the asbestos content in each sieve fraction, and 3) determine the amount of free asbestos unbound in serpentine rock. Results from the Bear Creek Quarry samples indicated that the average asbestos content in the road cover material was 19 percent (range 12 to 40 percent asbestos)[3]. The asbestos was approximately uniform throughout the whole range of sieve fractions. No free asbestos was detected at sieve sizes greater than 28 mesh (sieve opening 595 micrometers). The information from this sampling effort was included in an ARB report dated November 1988 (see Appendix B).

[3] Based on NIOSH Method 7400 using PML. Results reported in percent by weight.

From August 1998 to September 1998, ARB conducted air monitoring for NOA at various locations including Garden Valley. In November, ARB informed El Dorado County that air samples collected in the vicinity of Golden Sierra High School yielded asbestos concentrations that may pose a risk to human health. Subsequently, ARB conducted air monitoring in the Garden Valley area during August 1999 as part of an on-going asbestos air monitoring effort in El Dorado County. ARB collected 23 samples from seven monitoring stations located in Garden Valley area. All seven sites had average asbestos concentrations that could pose a risk to human health. ARB informed El Dorado County of these results in September 1999.

2.5.3 Department of Conservation

In 2001 the Department of Conservation, Division of Mines and Geology DMG contracted with the University of California-Davis to assemble a task force to develop guidelines for geologists who must evaluate property that may contain NOA. The work of the task force is ongoing and draft guidelines are currently undergoing peer review.

3.0 SOIL ANALYTICAL METHODS

A number of methods are available for soil asbestos analysis, although these methods do vary in detection limit, cost, and type of data obtainable (e.g., determination of fiber length). DTSC used Method CARB 435 on all soil samples and U.S. EPA funded TEM, PLM, and XRD on a select number of samples. The selected samples for TEM analysis included a variety of asbestos concentrations including samples in which Method CARB 435 PLM analysis did not detect asbestos fibers. The following subsections briefly describe the analytical methods used in this project and describe how the total asbestos concentration was calculated for size fractionated samples.

3.1 Percent Moisture and Size Fractionation

Samples were submitted to ALS Chemex, Inc., (Chemex) to determine the percent moisture of each sample and to size fractionate samples into two fractions; particles greater than 200 mesh (~ 75 microns) and particles less than 200 mesh. Samples were weighed, dried, and re-weighed to determine the percent moisture. The moisture content of soil is a factor when evaluating the likelihood of individual particles to become airborne. Samples that were size fractionated were weighed to determine the weight of each fraction so that the total asbestos concentration could be calculated. Chemex prepared samples (non-fractionated samples and fractionated samples greater than 200 mesh) in accordance to Method CARB 435. Samples were split using a Jones Riffle Box. The split samples to be processed were crushed in a Jaw Crusher with final milling using a Ring Milling method. Samples prepared by Chemex underwent various types of analysis by RJ Lee, Forensic Analytical, and EMSL.

3.2 Method CARB 435

Method CARB 435 was used to prepare samples and to determine the asbestos content of all soil samples (Note: The less than 200-mesh fraction for size fractionated samples did not undergo any mechanical alteration other than sieve analysis). Method CARB 435 protocol is designed for determining asbestos content in serpentine storage piles and surface applications such as roads and parking lots (this method is specified in Title 17, California Code of Regulations, section 94147). Method CARB 435 requires the sample be crushed to at least 200 mesh prior to analysis. It uses PLM to perform a quantitative analysis which involves the use of a 400-point count (point counting is a standard technique in petrography for determining the relative areas occupied by separate minerals in thin sections of rock). Method CARB 435 results are reported in "number-percent" not area percent. The number percent is the number of asbestos particles out of a total of 400 particles counted (Method CARB 435 400 point count has a detection limit of 0.25 percent: 1 fiber/400 = 0.0025 x 100 = 0.25%). See Appendix C for the Method CARB 435 protocol.

For the purposes of statistical evaluation, non-detect (ND) samples are given a "zero" asbestos concentration. Samples where asbestos fibers were identified in the sample, but not quantified (<0.25%), are given an asbestos value equal to ½ the detection limit of the analytical method, which is consistent with DTSC practices.

Some samples that were size fractionated resulted in one fraction with a detected amount of asbestos and one fraction not detecting asbestos above the detection limit of 0.25% asbestos. If no asbestos was detected (reported as ND) DTSC used the value of zero for that fraction. If asbestos was detected, but below the detection limit (0.25% for PLM and 0.1% for TEM), ½ the detection limit was used for the calculation.

3.3 Transmission Electron Microscopy (TEM)

TEM can detect smaller fibers as compared to light methods. TEM, SEM, and PLM can see fibers with diameters greater than 0.005, 0.05, and 0.5 microns, respectively. TEM provides more thorough data on fiber length and diameter distribution. TEM results are reported as a weight percentage. Several methods are also available for sample preparation. TEM used in this project followed U.S. EPA Method 600/R-93/116 and is included as Appendix D. TEM data is expressed as percent by weight based on fiber volume and density.

3.4 X-ray Diffraction (XRD)

XRD was used to determine the mineralogy of six selected samples. Two samples came from Bear Creek Quarry, two samples came from Garden Valley Aggregates, and two samples came from unpaved roads. While XRD is useful for mineral identification, regarding serpentine, it is not a good tool to quantify trace amounts of chrysotile within the lizardite or antigorite mineral matrix. Results are reported as percent by weight

3.5 Total Asbestos Calculation for Size Fractionated Samples

Samples that were size fractionated required that the total asbestos for the sample be calculated. The calculation followed the equation:

((C1*W1) + (C2*W2))/(W1 + W2) * 100 = Total Asbestos

Where:

C1 = Concentration of asbestos (%) in less than 200 mesh fraction
W1 = Weight of less than 200 mesh fraction
C2 = Concentration of asbestos (%) in greater than 200 mesh fraction
W2 = Weight of greater than 200 mesh fraction

Refer to Section 3.2 for a discussion on how ND and <0.25% asbestos samples were handled in the calculations.

4.0 SOIL SAMPLING PROCEDURES AND RESULTS

All samples collected on private property were collected with the consent of the property owner with the exception of Bear Creek Quarry and Garden Valley Aggregates, where access was obtained via Inspection Warrants. All samples were collected as discrete surface scrape samples (top 1-2 inches). Approximately one quart of sample was collected at each location.

The physical character of surface soils at all sites was heterogeneous (particles ranged from silt-sized particles to cobbles). The serpentine rock (when present) and possible asbestos distribution appeared to be homogeneous. In other words, asbestos fibers or bundles could be observed from time to time mixed in with the crushed road aggregate, but large areas of concentrated asbestos fibers or bundles were not observed. For this reason, few authoritative discrete samples were collected. Six authoritative discrete samples were collected at Bear Creek Quarry, under the advisement of a geologist. Most sample locations were recorded using the Global Positioning System (GPS). In a few cases the GPS instrumentation was unable to fix a location.

Selected soil samples were size fractionated in the laboratory into two fractions; particles greater than 75 microns (using a 200 mesh sieve) and particles less than seventy-five microns. The particles greater than seventy-five microns were analyzed via Method CARB 435 and particles less than seventy-five microns were analyzed using Method CARB 435 PLM procedures. The mass of the initial sample sieved was determined so the total concentration of NOA for the sample could be calculated. Size fractionation was conducted because particles less than 75 microns can become airborne given specific wind conditions or human activities, and particles greater than 75 microns may become airborne in the future if mechanical crushing were to occur (e.g., car tires running over serpentine).

The following sections will provide information on sample location, collection, and results for each major source area evaluated. Analytical interpretation will distinguish size-fractionated samples (hereafter referenced as fractionated) from intact samples (hereafter referenced as non-fractionated). For the purposes of statistical evaluation non -detect samples are given a “zero” asbestos concentration, and samples where asbestos fibers were seen, but not quantified, are given an asbestos value equal to ½ the detection limit of the analytical method, which is consistent with DTSC practices. Section 4.7 provides a comparison of PLM and TEM results and Section 4.8 provides a comparison of the fractionated samples. Table 14 contains a summary of all ranges and averages identified in this section. All results described are based on EMSL data.

4.1 Bear Creek Quarry

Site Description and Location

The Bear Creek Quarry is an active serpentine quarry located at the end of Bear Creek Road off Highway 193, and is within one-half mile of the intersection of Bear Creek Road and Meadow Brook Road (approximately two miles northeast of Golden Sierra High School). The site is approximately 26 acres in size, with the actual disturbed portion of the quarry being a slightly smaller area. Bear Creek Quarry topography is somewhat tiered and contains a pit where current mining operations are located. The quarry is located in a sparsely vegetated area with plant species typical of serpentine deposits. The site has several pits where mining or processing activities occurred and also contained multiple serpentine product piles of various volumes. Numerous pieces of heavy equipment were observed, consistent with operating an active mine. Several physical hazards were observed at the mine including active and inactive heavy equipment, high walls, and product piles. DTSC staff observed water being used for dust suppression during mining operations at the site. There are several residential properties within one mile of the site.

Sample Collection

The team that collected samples at the Bear Creek Quarry was comprised of DTSC staff and members from the Superfund Technical Assistance and Response Team (START), from U.S. EPA’s contractor, Ecology and Environment, Inc. Members of START included a geologist who documented sample geology and a person to collect samples. DTSC staff logged sample locations using GPS. Figure 3 shows the general location of Bear Creek Quarry and the sample numbers associated with the quarry.

Twenty-nine surface samples were collected by START using disposable trowels and placed in one-quart plastic jars. Discrete samples were collected from the top 1-2 inches of the surface. Twenty-three random samples and six authoritative samples were collected. Four of the twenty-nine samples collected were co-located duplicate samples. One sample, GV-27, was not accounted for when the samples were being packaged to be sent to the laboratory and is considered lost. This loss of this sample was not considered significant because there were enough samples collected from the Bear Creek Quarry to adequately screen it for asbestos content. Each sample was sealed and labeled. Samples were prepared for shipment at DTSC's regional office in Sacramento.

Soil Sample Results

Twenty-eight surface soil samples were submitted for analytical evaluation of which seven samples were fractionated creating a total of thirty-five samples. The percent moisture was determined for all samples and ranged from 0.01% to 7.3%. Twenty-one non-fractionated samples were analyzed by PLM and the asbestos concentrations for these samples ranged from less than 0.25% to 12% with a mean concentration of 1.7%. For the fractionated samples, the PLM asbestos concentrations for the greater than 200 mesh samples ranged from 0.5% to 4.3% with a mean concentration of 2.0%, and the PLM asbestos concentrations for the less than 200 mesh samples ranged from 0.5 % to 15 % with a mean concentration of 3.3%. The calculated total asbestos concentration for the fractionated samples based on PLM analysis ranged from 0.51% to 4.7% with a mean concentration of 2.1%. Chrysotile was the only form of asbestos PLM analysis identified for samples with detectable concentrations of asbestos.

Ten non-fractionated samples were analyzed by TEM and the asbestos concentrations for these samples ranged from 1.7% to 7.3% with a mean concentration of 4.3%. Six fractionated samples were analyzed by TEM. The asbestos concentrations for the greater than 200 mesh samples ranged from 1.1% to 4.9% with a mean concentration of 2.3%, and the TEM asbestos concentrations for the less than 200 mesh samples ranged from 0.67 % to 4.9 % with a mean concentration of 2.4%. The calculated total asbestos concentration for the fractionated samples based on TEM analysis ranged from 1.1% to 4.6% with a mean concentration of 2.3%. Chrysotile was the only form of asbestos TEM identified for samples with detectable concentrations of asbestos.

Two samples (GV-6 and GV-22) were analyzed by XRD. Lizardite was the primary serpentine matrix with minor amounts of chrysotile also present. However, due to severe peak overlap the amount of chrysotile could not be quantified.

The results for percent moisture are shown in Table 1, analytical results for PLM and TEM asbestos concentrations are shown in Table 2, the calculated total asbestos for the size fractionated samples are shown in Table 3, and the results of the XRD analysis is shown in Table 4.

4.2 Garden Valley Aggregates

Site Description and Location

The GVA site is an inactive serpentine quarry located at the southwest corner of Mt. Murphy Road and Marshall Road. The site is approximately 12 acres in size, but the disturbed area is less than 12 acres. The site is generally flat, but the western part of the site is comprised of a disturbed slope (approximately 50 feet high), which consists of outcroppings, broken rock and fine aggregate. The floor of the quarry is well compacted with aggregate size serpentine. The southeastern part of the quarry appears to contain imported fill covering a portion of the site. The site is currently used to store several pieces of mining equipment. The entrance to GVA is an unpaved serpentine road several hundred yards long and leads to a mobile home trailer. The undisturbed areas of the GVA are sparsely vegetated with plants and bushes typical in serpentine deposits.

Sample Collection

Thirty-five surface soil samples were collected by DTSC staff using disposable trowels and placed in one-quart plastic bottles. All samples were collected from the upper 1-2 inches of the ground surface. DTSC staff devised a grid and collected samples at regular intervals. Samples were collected in this manner because the site was flat and the distribution of serpentine rock appeared to be uniform. No authoritative samples were collected due to the lack of concentrated areas of obvious asbestos fibers, although a geologist observed asbestos fibers (the fiber volume was too small to be collected as a "sample"). Two samples, A-34 and A-35 were collected from the unpaved road leading into GVA. The GVA sampling team did not identify duplicate samples. Figure 3 shows the general location of Garden Valley Aggregates and the sample numbers associated with the quarry.

Soil Sample Results

Thirty-five surface soil samples were submitted for analytical evaluation with eight of these samples being fractionated creating a total of forty-three samples. Percent moisture of the GVA samples ranged from 0.29% to 4.6%. Twenty-seven non-fractionated samples were analyzed by PLM and the asbestos concentrations for these samples ranged from less than 0.25% to 4.5% with a mean concentration of 1.2%. For the fractionated samples, the PLM asbestos concentrations for the greater than 200 mesh samples ranged from less than 0.25% to 2.2% with a mean concentration of 1.3%. The PLM asbestos concentrations for the less than 200 mesh samples ranged from less than 0.25 % to 1.8 % with a mean concentration of 0.94%. The calculated total asbestos concentration for the fractionated samples based on PLM analysis ranged from 0.14% to 2.0% with a mean concentration of 1.3%. Chrysotile was the only form of asbestos PLM analysis identified for samples with detectable concentrations of asbestos.

Nine non-fractionated samples were analyzed by TEM and the asbestos concentrations for these samples ranged from less than 0.48% to 2.7% with a mean concentration of 1.1%. The asbestos type for these samples was chrysotile. Eight fractionated samples were analyzed by TEM, which detected chrysotile in all eight samples, tremolite in four samples, and anthophylite in one sample. For samples where chrysotile asbestos was detected, the asbestos concentrations for the greater than 200 mesh samples ranged from 0.56% to 1.1% with a mean concentration of 0.84%, and the results for the less than 200 mesh samples ranged from 0.17 % to 1.2 % with a mean concentration of 0.71%. The calculated total asbestos concentration for the fractionated samples based on TEM analysis ranged from 0.58% to 1.1% with a mean concentration of 0.73%. Of the four samples where tremolite was detected, only one sample could be quantified with a concentration of 1.7% asbestos. Anthophyllite was detected in one sample, but could not be quantified.

Two samples (A-13 and A-33) were analyzed by XRD. Lizardite was the primary serpentine phase with minor amounts of chrysotile also present. However, due to severe peak overlap the amount of chrysotile could not be quantified.

The results for percent moisture are shown in Table 1. The analytical results for PLM and TEM asbestos concentrations are shown in Table 5. The calculated total asbestos concentrations for the size-fractionated samples are shown in Table 6, and the results of the XRD analysis is shown in Table 4.

4.3 Unpaved Roads

Site Description and Location

An initial evaluation of roads by DTSC indicated that the GVSDA has 112 unpaved roads totaling approximately 25 miles. Evaluating and collecting samples from all of the unpaved roads within the GVSDA was not possible. Roads were selected based on the following criteria; access, traffic flow, location relative to the GVSDA, and its location relative to the Golden Sierra High School. DTSC collected samples from Poohs Path, Fair Pines Lane, Slowdusty Road, Wabasso, Irish Lane, Old Sawmill Road, Manhattan Creek Road, Gamble’s Pass, Tupelo Road, Brumarba Heights Road, Creek Park Ranch Road, Sagebrush, Oak Lane, and Blue Ledge Lane. Garden View Road and Garden View Court were also sampled, and will be described in greater detail in section 4.4 because of their close proximity to the Golden Sierra High School.

Of the unpaved roads evaluated, most roads appeared to have a uniform distribution of aggregate. Some roads had course material on the sides and center, but contained pulverized rock in the tire ruts.

A geologist evaluated the aggregate material on each road. If the road aggregate contained material other than serpentine (e.g., crushed slate or limestone) then only one or two samples were collected from that road. The rationale for collecting samples from non-serpentine roads within the GVSDA was based on DTSC’s lack of historical information regarding aggregate use. If serpentine aggregate was used in the past on a particular road, which is now covered with a non-serpentine aggregate, then DTSC would be able to obtain limited information regarding the potential for mixing of serpentine and non-serpentine material. Roads that are currently covered with non-serpentine material include Gambles Pass, Tuppelo Drive, and Old Sawmill Road. The other roads evaluated were either partially or completely covered with serpentine aggregate (some serpentine roads had sections that were covered with non-serpentine material).

Sample Collection

Fifty-two samples were collected from the top 1-2 inches of the road surface. Sample locations were determined by where property owners gave access to DTSC to collect soil samples from their portion of the selected road. Once DTSC established the section of road that it was allowed to sample, staff selected a random point long that section. A quart of sample was collected and if possible, the location noted using GPS. Approximate sample locations were marked on parcel maps.

Sample Results

This section will discuss the sample results for selected unpaved roads. Sample results for individual roads can be identified by reviewing Figure 4 to identify the sample numbers for those samples collected from a specific road and finding the corresponding sample results in Table 6 for these sample numbers. A higher number of samples were collected from Garden View Road and Garden View Court due to their proximity to Golden Sierra High School.

Fifty-two surface soil samples were submitted for analytical evaluation with seventeen of these samples being fractionated creating a total of sixty-nine samples. Percent moisture of the unpaved road samples ranged from 0.06% to 1.9%. Thirty-five non-fractionated samples were analyzed by PLM and the asbestos concentrations for these samples ranged from non-detect to 1.5% with a mean concentration of 0.34%. For the fractionated samples, the PLM asbestos concentrations for the greater than 200 mesh samples ranged from non-detect to 4.0% with a mean concentration of 0.69%. The PLM asbestos concentrations for the less than 200 mesh samples ranged from less than 0.25 % to 4.0% with a mean concentration of 1.9%. The calculated total asbestos concentration for the fractionated samples based on PLM analysis ranged from 0.10% to 3.9% with a mean concentration of 0.77%. Chrysotile was the only form of asbestos PLM analysis identified for samples with detectable concentrations of asbestos.

Eighteen non-fractionated samples were analyzed by TEM. The asbestos concentrations for these samples ranged from less than 0.1% to 5.3% with a mean concentration of 1.7%. Eight fractionated samples were analyzed by TEM. The asbestos concentrations for the greater than 200 mesh samples ranged from less than 0.1% to 5.5% with a mean concentration of 2.6%, and the TEM asbestos concentrations for the less than 200 mesh samples ranged from 0.13 % to 7.7% with a mean concentration of 3.8%. The calculated total asbestos concentration for the fractionated samples based on TEM analysis ranged from 0.23% to 5.3% with a mean concentration of 2.7%. Chrysotile was the only form of asbestos TEM identified for samples with detectable concentrations of asbestos. The less than 200 mesh fraction of sample GV-90 was not analyzed because it was used by the U.S. EPA asbestos audit team and not available for analysis by EMSL.

Two samples (GV-90 and GV-92) were analyzed by XRD. Lizardite was the primary serpentine phase with minor amounts of chrysotile also present. However, due to severe peak overlap the amount of chrysotile could not be quantified.

The results for percent moisture are shown in Table 1, the analytical results for PLM and TEM asbestos concentrations are shown in Table 7, the calculated total asbestos for the size fractionated samples are shown in 8, and the results of the XRD analysis is shown in Table 4.

4.4 Garden View Road and Garden View Court

Site Description and Location

Garden View Road is a side road to the east-west Marshall Road in Garden Valley. Garden View Road borders Golden Sierra High School on the east. This road was paved for approximately 300 feet where the pavement ends. The subsequent road is unpaved, not maintained and appears to be partially covered with serpentine material. The serpentine aggregate used on this road has been reduced to a finer grained material and is somewhat homogeneous. A section of Garden View Road is adjacent to the school's soccer field. Garden View Court is a side road off of Garden View Road that bears west. The serpentine material on this road is also somewhat homogeneous. Garden View Court is unpaved and borders Golden Sierra High School to the south. A small section of this road is adjacent to the school football field.

Sample Collection

Sixteen samples were collected from the top 1-2 inches of the road surface and placed in one-quart plastic bottles. Samples were collected at approximately 100-foot intervals to ensure adequate sampling of these areas. No samples on Garden View Road were collected south of the intersection of Garden View Road and Garden View Court.

Sample Results

Data for all unpaved roads were presented in the preceding section. However, DTSC is also providing information on Garden View Road and Garden View Court because of their location to the Golden Sierra High School. Data from this section were included in the statistical evaluation presented in the prior section.

Sixteen surface soil samples were submitted for analytical evaluation with six of these samples being fractionated creating a total of twenty-two samples. The percent moisture ranged from 0.06% to 0.67%. Ten non-fractionated samples were analyzed by PLM and the asbestos concentrations for these samples ranged from less than 0.25% to 1.5% with a mean concentration of 0.52%. For the fractionated samples, the PLM asbestos concentrations for the greater than 200 mesh samples ranged from less than 0.25% to 0.75% with a mean concentration of 0.25%. The PLM asbestos concentrations for the less than 200 mesh samples ranged from 0.25 % to 4.0 % with a mean concentration of 2.0%. The calculated total asbestos concentration for the fractionated samples based on PLM analysis ranged from 0.24% to 0.71% with a mean concentration of 0.42%. Chrysotile was the only form of asbestos PLM analysis identified for samples with detectable concentrations of asbestos.

Seven non-fractionated samples were analyzed by TEM. The asbestos concentrations for these samples ranged from 0.48% to 4.9% with a mean concentration of 1.9%. Two fractionated samples were analyzed by TEM. The asbestos concentrations for the greater than 200 mesh samples ranged from 0.58% to 1.8% with a mean concentration of 1.3%, and the TEM asbestos concentrations for the less than 200 mesh samples ranged from 0.13% to 4.0% with a mean concentration of 2.1%. The calculated total asbestos concentration for the fractionated samples based on TEM analysis ranged from 0.54% to 2.1% with a mean concentration of 1.3%. Chrysotile was the only form of asbestos TEM identified for samples with detectable concentrations of asbestos.

4.5 Greenwood Road, Garden Valley Road, Marshall Road, and Highway 193 School Bus Stops within the GVSDA

Site Description and Location

There are several paved roads used by the Black Oak Mine School District as school bus routes to pickup and drop-off children. Many of these bus stops are used several times during the day. Several of these school bus stops have serpentine aggregate along the road shoulder where the bus stops are located, or at the intersection of a paved road and an unpaved road or driveway. According to the Black Oak Mine School District's (School District) Transportation Director, the School District has discontinued using serpentine rock at its bus stops.

Samples were collected at locations where Blue Lane, Greenwood Lane, and Tuppelo Drive intersect Greenwood Road. Samples were collected at the Intersections of Highway 193 and Twin Pines, and Highway 193 and Fair Pines Lane. Samples were collected at the locations where Garden Park Drive, Pooh's Path, Yellow Brick Road, and Water Willow Lane intersect Garden Valley Road

Sample Collection

Thirteen samples were collected from the top 1-2 inches of the road surface and placed in one-quart plastic jars. Samples were collected in the approximate area that a school bus would stop when on-loading or off-loading children. Samples were collected at several bus stops that did not have serpentine aggregate. The rationale for collecting samples from non-serpentine bus stops within the GVSDA was based on DTSC's lack of historical information regarding aggregate use. Figure 5 shows the location and sample numbers associated with the school bus stops evaluated.

Sample Results

Thirteen surface soil samples were submitted for analytical evaluation with eight of these samples being fractionated creating a total of twenty-one samples. The percent moisture was determined for all samples and ranged from 0.05% to 1.3%. Five non-fractionated samples were analyzed by PLM and the asbestos concentrations for these samples ranged from non-detect to 0.5% with a mean concentration of 0.10%. For the fractionated samples, the PLM asbestos concentrations for the greater than 200 mesh samples ranged from non-detect to 1.2% with a mean concentration of 0.32%. The PLM asbestos concentrations for the less than 200 mesh samples ranged from less than 0.25% to 2.8% with a mean concentration of 1.4%. The calculated total asbestos concentration for the fractionated samples based on PLM analysis ranged from 0.02% to 1.2% with a mean concentration of 0.41%. Chrysotile was the only form of asbestos PLM analysis identified for samples with detectable concentrations of asbestos.

Five non-fractionated samples were analyzed by TEM and the asbestos concentrations for these samples ranged from less than 0.10% to 2.4% with a mean concentration of 0.59%. Eight fractionated samples were analyzed by TEM. The asbestos concentrations for the greater than 200 mesh samples ranged from 0.13% to 4.3% with a mean concentration of 1.4%, and the TEM asbestos concentrations for the less than 200 mesh samples ranged from less than 0.10% to 5.9% with a mean concentration of 2.0%. The calculated total asbestos concentration for the fractionated samples based on TEM analysis ranged from 0.13% to 4.1% with a mean concentration of 1.4%. TEM identified chrysotile, actinolite (one sample), and tremolite (one sample) with detectable concentrations of asbestos, however, the concentrations of actinolite and tremolite were below the level that could be quantified.

The results for percent moisture are shown in Table 1, the analytical results for PLM and TEM asbestos concentrations are shown in Table 9, and the calculated total asbestos for the size fractionated samples are shown in Table 10.

4.6 Road Cut along Marshall Road

Site Description and Location

There are several large road cuts along Marshall Road west of Garden Valley Aggregates. The road cut evaluated is approximately 200 feet long and 60 feet high and has a concrete drainage ditch at the base.

Sample Collection

Eight samples were collected as surface scrapes (top 1-2 inches) at the base of a road cut on the south side of Marshall Road. Sample volume was generally less than one quart due to limited amount of fines along the base of the road cut.

Sample Results

Eight surface soil samples were submitted for analytical evaluation with two of these samples being fractionated creating a total of ten samples. The percent moisture as determined for all samples and ranged from 0.85% to 2.7%. Six non-fractionated samples were analyzed by PLM and the asbestos concentrations for these samples ranged from less than 0.25% to 0.5% with a mean concentration of 0.27%. For the fractionated samples, the PLM asbestos concentrations for the greater than 200 mesh samples ranged from less than 0.25% to 0.25% with a mean concentration of 0.19%. The PLM asbestos concentrations for the less than 200 mesh samples ranged from less than 0.25% to 1.0% with a mean concentration of 0.56%. The calculated total asbestos concentration for the fractionated samples based on PLM analysis ranged from 0.17% to 0.24% with a mean concentration of 0.21%. Chrysotile was the only form of asbestos PLM analysis identified for samples with detectable concentrations of asbestos.

Four non-fractionated samples were analyzed by TEM and the asbestos concentrations for these samples ranged from less than 0.10% to 0.61% with a mean concentration of 0.25%. TEM identified chrysotile, actinolite (one sample), and actinolite/tremolite (one sample) with detectable concentrations of asbestos. The asbestos concentration for the sample containing actinolite could not be quantified. The asbestos concentration for the sample containing actinolite/tremolite was 0.61%

The results for percent moisture are shown in Table 1, the analytical results for PLM and TEM asbestos concentrations are shown in Table 11, and the calculated total asbestos for the size fractionated samples are shown in Table 12.

4.7 PLM and TEM

DTSC and U.S. EPA agreed to use both PLM and TEM to evaluate asbestos concentration in soil samples. PLM offered DTSC a cost effective way of screening a large number of soil samples, and is the analytical method ARB uses to evaluate serpentine and ultramafic rock for asbestos content. TEM has the ability to resolve fibers less than 0.5 microns in diameter and has a lower detection limit than PLM. Generally, TEM analysis is expected to report higher asbestos concentrations than PLM analysis for the same sample because of its ability to resolve smaller fibers. While each method offers advantages and disadvantages, DTSC and U.S. EPA agreed that a dual analysis approach would provide useful data for samples that contained asbestos concentrations near or below the detection limit of PLM. TEM and PLM are further discussed in Section 5.2.

TEM analysis indicated levels of asbestos greater than 0.25 percent for approximately 74 percent of the PLM samples that reported less than 0.25 percent. Table 13 identifies PLM sample results less than the detection limit and the corresponding TEM asbestos concentration.

4.8 Size Fractionated Samples

A comparison of all size fractionated results indicate that the less than 200 mesh samples tended to contain slightly higher levels of asbestos than the greater than 200 mesh samples. Specifically, the less than 200 mesh samples contained higher asbestos concentrations sixty-eight percent of the time for samples analyzed by PLM. The less than 200 mesh samples contained higher asbestos concentrations sixty-two percent of the time for samples analyzed by TEM.

5.0 QUALITY CONTROL AND QUALITY ASSURANCE

5.1 Uncertainty with RJ Lee and Forensic Analytical Data

In June 2000, DTSC contracted with Chemex to conduct the following activities:

- Prepare 42 samples using procedures outlined in Method CARB 435,
- determine the percent moisture of each sample, and
- Size-fractionate 42 samples into two fractions; particles greater than 200 mesh (~ 75 microns) and particles less than 200 mesh (see Sections 3.1 and 3.2).

Samples were submitted to Chemex in two batches; one after the August 2000 sampling event and one after the September 2000 sampling event. The prepared samples (~ one pint of sample) were shipped to RJ Lee for PLM analysis. Chemex archived all remaining samples.

DTSC contracted with RJ Lee in June 2000 to conduct PLM on prepared samples following Method 435 PLM procedures. RJ Lee received samples submitted by Chemex and determined that some of the size-fractionated samples were not properly prepared. Specifically, the greater than 200 mesh samples were not crushed following Method CARB 435 procedures. RJ Lee returned these samples to Chemex who properly prepared and resubmitted them to RJ Lee. RJ Lee analyzed these samples via Method CARB 435 and completed all analysis by October 2000. Results provided by RJ Lee were significantly lower than historic results reported by U.S. EPA and ARB for the Garden Valley area during various sampling events in the late 1980s.

U.S. EPA contracted with Forensic Analytical to conduct TEM analysis on the Garden Valley samples after RJ Lee's work was completed. Furthermore, for the purposes of QA/QC DTSC and U.S. EPA believed it was prudent to have Forensic Analytical analyze eighteen samples by PLM following Method CARB 435 procedures. In February 2001 Forensic Analytical reported TEM results which were similar to RJ Lee's PLM results. However, Forensic Analytical PLM results were significantly higher than RJ Lee's PLM results. Nine of the eighteen samples had results that differed by an order of magnitude. Chrysotile was the only asbestos type reported by either lab. Appendix E provides the RJ Lee PLM results. Appendix F provides the Forensic Analytical PLM and TEM results.

During this investigation, DTSC observed differences between the RJ Lee PLM and the Forensic Analytical PLM results. Factors that may explain the difference between the RJ Lee PLM results and the Forensic Analytical PLM results include:

- RJ Lee used the appropriate refractive index oil to identify the asbestos type. However, according to RJ Lee, a refractive index “liquid” that was a ten-percent solution of hydrochloric acid, was used to conduct the actual point count. Scientists knowledgeable in asbestos and/or PLM indicated that hydrochloric acid might dissolve or change the optical properties of chrysotile asbestos. If this explanation were true, one would expect lower asbestos concentration being reported than the true concentration.

- Microscopists may have a difficult time distinguishing chrysotile asbestos fibers from “fiber-like” cleavage fragments of lizardite, which may lead to erroneous reporting of higher asbestos concentration for the sample analyzed.

DTSC and U.S. EPA could not determine which laboratory results were the most accurate. U.S. EPA agreed to submit the Garden Valley samples to EMSL to analyze all samples using PLM following Method CARB 435 procedures and the same 106 samples Forensic Analytical analyzed via TEM following EPA Method 600.R-93/116 procedures. EMSL was selected because they had recently passed U.S. EPA’s asbestos laboratory audit and have experience analyzing environmental NOA samples. Furthermore, it was agreed that acid would not be used during any stage of the analysis for either analytical method.

Upon receipt of the soil samples from Forensic Analytical, EMSL reported three of the five shipping containers had some broken sample bags. The impacted samples were associated with both quarries. DTSC contacted Chemex who still retained the original archived samples. Chemex had enough material to prepare and ship to EMSL eleven of the twenty-two affected samples. These samples were re-submitted to EMSL for analysis. Chemex indicated that there were not enough samples fines to produce the less than 200-mesh fraction, therefore these eleven samples could not be re-submitted, for analysis. However, EMSL proceeded to analyze the eleven samples because they believed these samples were not impacted by potential cross-contamination. These samples are identified as “qualified” (J) in the result tables. In all, thirty samples were qualified as estimated for several procedural reasons identified in US EPA’s Final Report. In the professional judgement of U.S. EPA validators, the uncertainty in the results did not warrant rejecting the data.

Data provided by EMSL was subject to data validation by U.S. EPA’s contractor. Data was validated according to the guidelines outlined in the *U.S. EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*.

5.2 Uncertainty with TEM and PLM Comparison

There is increased uncertainty when directly comparing TEM USEPA method 600/R-93/116 and PLM CARB 435 method. The inherent discrepancies between the two methods included: 1) PLM not being able to resolve fibers with a diameter less than 0.5 microns, 2) TEM sample size (minute when compared to the sample volume used for PLM), and 3) the different way each method determines asbestos percentage. PLM data is reported as numerical percent and TEM data is reported as percent by weight.

The uncertainty between the PLM and TEM methods was observed in the Forensic Analytical data. Forensic Analytical provided an explanation why their PLM results differed significantly from their TEM results for the same samples. Forensic Analytical stated that Method CARB 435 PLM analysis, which uses a point count method to determine percentage, is not directly comparable to TEM, which uses a weight percentage method, unless you assume the density of the matrix is similar to the density of asbestos. However, the density of the matrix is often different than the density of asbestos. TEM analysis corrects for this variability by projecting volumes and modifying densities based on mineralogy while PLM does not. See Appendix G for Forensic Analytical's letter of explanation.

5.3 Duplicates

The purpose of collecting duplicate samples was to the reproducibility of the data. Seven of the one hundred thirty-seven samples collected were duplicate samples. For each similar type of analysis there was general agreement with original and duplicate samples. Duplicate samples were not identified by the Garden Valley Aggregate sampling team.

5.4 Audits

In addition to the analytical concerns detailed in Section 5.1, DTSC and U.S. EPA also questioned the QA/QC procedures of the individual laboratories. U.S. EPA had assembled an audit team specifically for reviewing procedures at asbestos laboratories. Forensic Analytical has successfully met the requirements of the audit team prior to the Garden Valley project. U.S. EPA agreed to send the audit team to RJ Lee's PLM laboratory in San Leandro, California. The audit of RJ Lee's PLM laboratory by U.S. EPA revealed procedural weaknesses with regard to a lack of an on-site QA/QC program, compliance with laboratory Standard Operating Procedures and methodology, sampling handling, record keeping, and incomplete documentation of analytical results. However, the audit team was unable determine if RJ Lee's use of acid was appropriate. The U.S. EPA audit reports are found in Appendix H.

Conclusions

Bear Creek Quarry, Garden Valley Aggregates, selected unpaved roads, school bus stops, and one road cut were evaluated within the GVSDA. Results of the investigation determined that low percentage levels of asbestos is associated with serpentine rock found throughout the Garden Valley area and no single source was found to contain "significantly higher" levels of asbestos as compared to the other sources evaluated. NOA concentrations found in this study are lower than results reported by the U.S. EPA and ARB in the late 1980s. The lower results may be due to the effectiveness of the 1990 ATCM limiting asbestos concentrations to below five percent and the desire of quarry owners to avoid areas of the quarry that may contain high concentrations of asbestos.

DTSC did not sample all unpaved serpentine roads and did not sample serpentine driveways, however, DTSC expects that serpentine rock found throughout the GVSDA contains levels of asbestos consistent with the findings of this study. Chrysotile was the major asbestos type found throughout the GVSDA, however, amphibole asbestos was detected in a few samples.

Significant delays in DTSC reporting soil sample results were due to several data quality issues. DTSC and U.S. EPA agreed not to release any data until all the quality control/quality assurance issues could be resolved. The use of hydrochloric acid by RJ Lee during the PLM analysis and Forensic Analytical during the TEM analysis may have adversely biased low reported chrysotile concentrations. Furthermore, the difficulty of distinguishing asbestos fibers from sample matrix cleavage fragments may have biased high reported asbestos concentrations by Forensic Analytical for the eighteen QA/QC samples.

DTSC and U.S. EPA agreed to resolve the data concerns by using a third lab, EMSL, which had successfully met the requirements of a U.S. EPA's asbestos audit and is experienced in analyzing environmental samples. EMSL did not use hydrochloric acid during samples analysis. DTSC considers the PLM and TEM analytical results provided by EMSL to be most reliable.

PLM (using Method CARB 435) and TEM (using U.S. EPA Method 600/R-93/116) analysis were used to determine asbestos concentration in soil samples. Generally, TEM analysis is expected to report higher asbestos concentrations than PLM analysis for the same sample because of its ability to identify smaller fibers. While each method offers advantages and disadvantages, DTSC and U.S. EPA agreed that a dual analysis approach would provide useful data for samples that contained asbestos concentrations near or below the detection limit of PLM. TEM results exceeded the PLM detection limit approximately 74 percent of the time for PLM samples reported as less than 0.25 percent

Randomly selected samples were sieved into two fractions. One fraction-represented fines (dust) which when disturbed could immediately release asbestos fibers into the air.

The other fraction represented aggregate which indicated asbestos concentrations may be release at a future data should mechanical crushing continue. Analytical results of the size fractionated samples indicate that the less than 200 mesh fraction (dust), tended to contain slightly higher asbestos concentrations than its corresponding greater than 200 mesh fraction.

Recommendations

The mere presence of NOA does not mean asbestos fibers are being entrained into the air. There are a number of factors that DTSC believes influence the concentration of asbestos fibers released to the atmosphere. These factors include the frequency and duration that NOA is disturbed by human or natural means, moisture content of NOA sources, climatic conditions, particle size distribution of NOA sources, and asbestos concentration of source material (serpentine rock in the case of the Garden Valley study).

DTSC has identified numerous sources of low percentage levels of NOA throughout the GVSDA. The Garden Valley SAP identified 0.25 percent asbestos in soil as the action level leading to either air monitoring or additional investigation. However, it is not practical or cost effective to conduct focused air monitoring at all the locations where soil asbestos content exceeds 0.25 percent. DTSC believes that the highest priority for further studies is the unpaved serpentine roads.

Based upon results of this study and air sampling conducted by DTSC and the ARB, DTSC believes that the serpentine covered roads in the GVSDA are likely to be the primary source of asbestos found in ambient air samples. Therefore, DTSC plans to conduct focused air monitoring studies associated with the serpentine roads. The air monitoring studies will be completed in order to gain information on the magnitude of emissions in proximity to the roads and on the contribution of serpentine covered roads to the NOA emissions within the GVDSA.

At this time, DTSC does not intend to pursue additional studies at Bear Creek Quarry. The asbestos content of serpentine rock used for surface application is subject to regulation by ARB's ATCM and dust emissions from the Bear Creek Quarry are subject to regulation by El Dorado County's Air Pollution Control District. Furthermore, air data collected over the past several years indicates that the predominant wind direction at Bear Creek Quarry is away from the Golden Sierra High School.

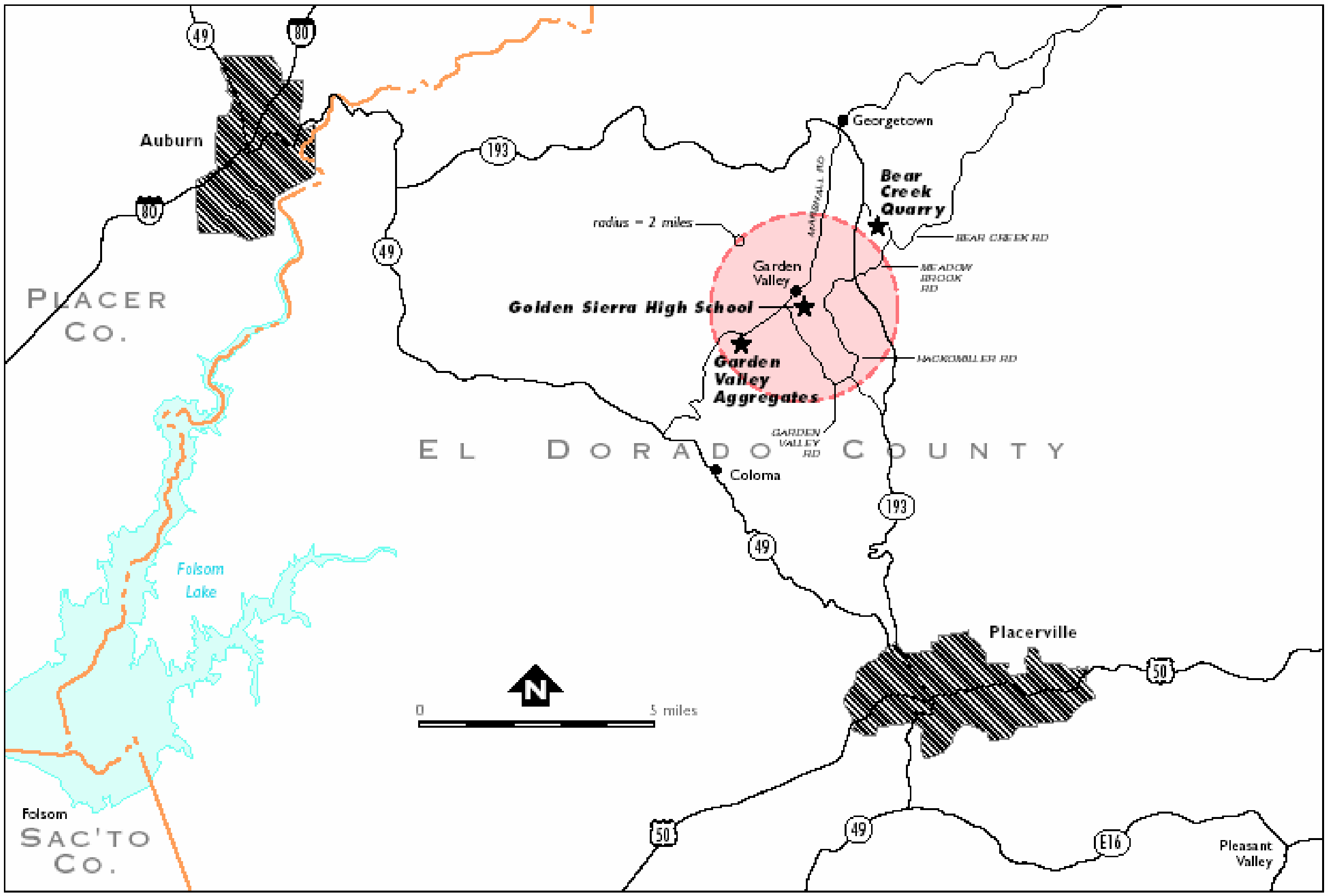
DTSC does not intend to pursue additional studies at Garden Valley Aggregates at this time. Garden Valley Aggregates is an inactive quarry and the State Mining and Geology Board has recently adopted a reclamation plan for Garden Valley Aggregates.

DTSC supports the Black Oak Mine School District's continuing efforts to cover existing serpentine rock at its school bus stops with limestone or other suitable material free of asbestos. DTSC recommends that remaining bus stops surfaced with serpentine rock be resurfaced with limestone or other suitable material. DTSC does not intend to pursue additional studies at school bus stops at this time.

DTSC recommends that any property owner who may disturb NOA sources take appropriate measures to reduce their potential exposure to asbestos fibers, including surfacing unpaved roadways with non-serpentine material that is free of asbestos. The ARB has identified a number of measures that can reduce an individual's exposure to asbestos. These measures can be found on ARB's Web page: http://www.arb.ca.gov/toxics/Asbestos/general.htm.

FIGURES

References: *Northern California Atlas & Gazeteer*, DeLorme, 1998; *Garden Valley Site Discovery Area – Map of Quarry Locations*, [published by ...], [date]



Ecology and Environment, Inc.

Dr. No: 09.0530.EDSF.XX.b
TDD: 09-0003-0004
PAN: 0530-EDSF-XX
Date: 12/12/2000
File: Z.54

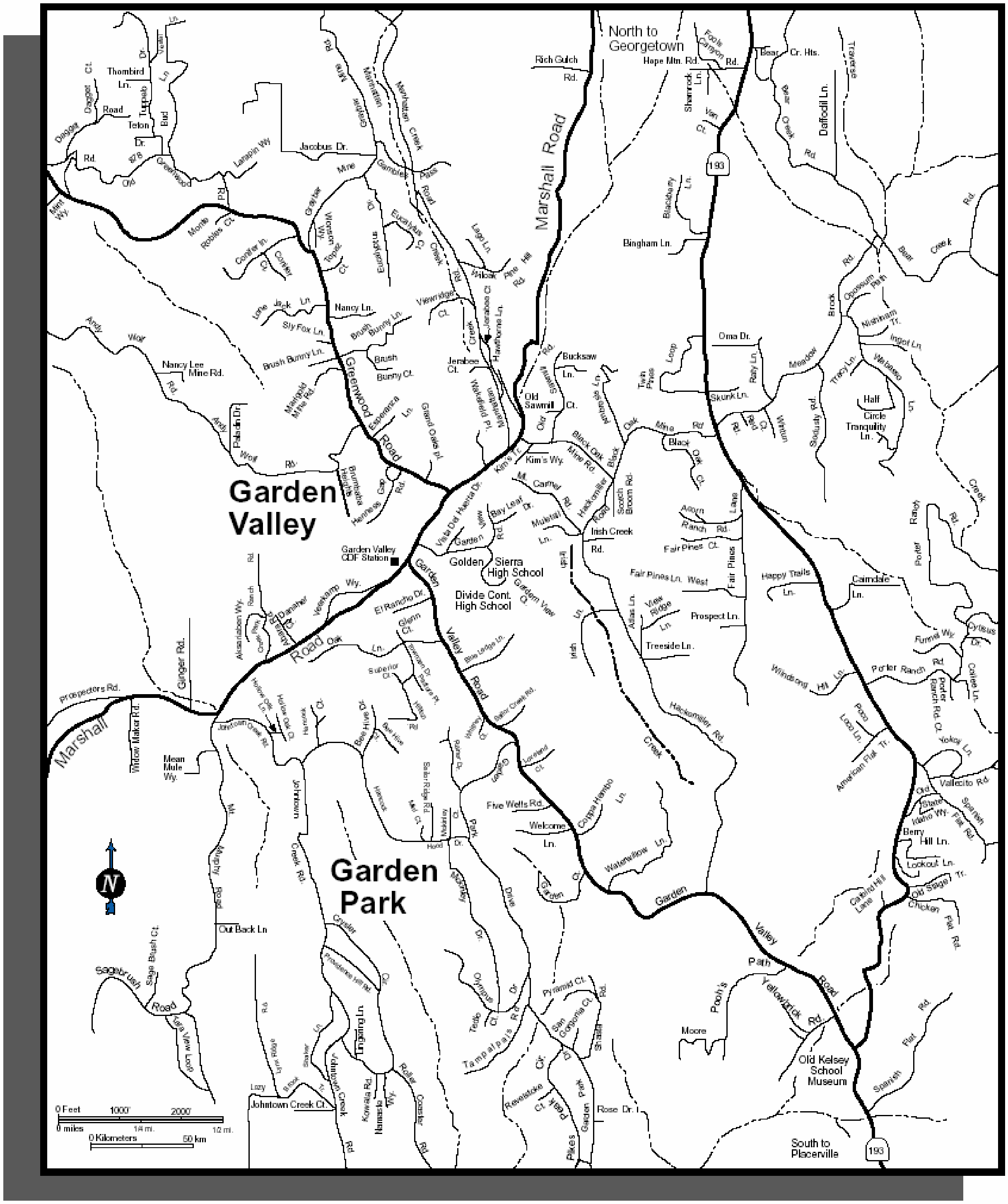
Figure 1

Regional Setting

El Dorado Site Discovery

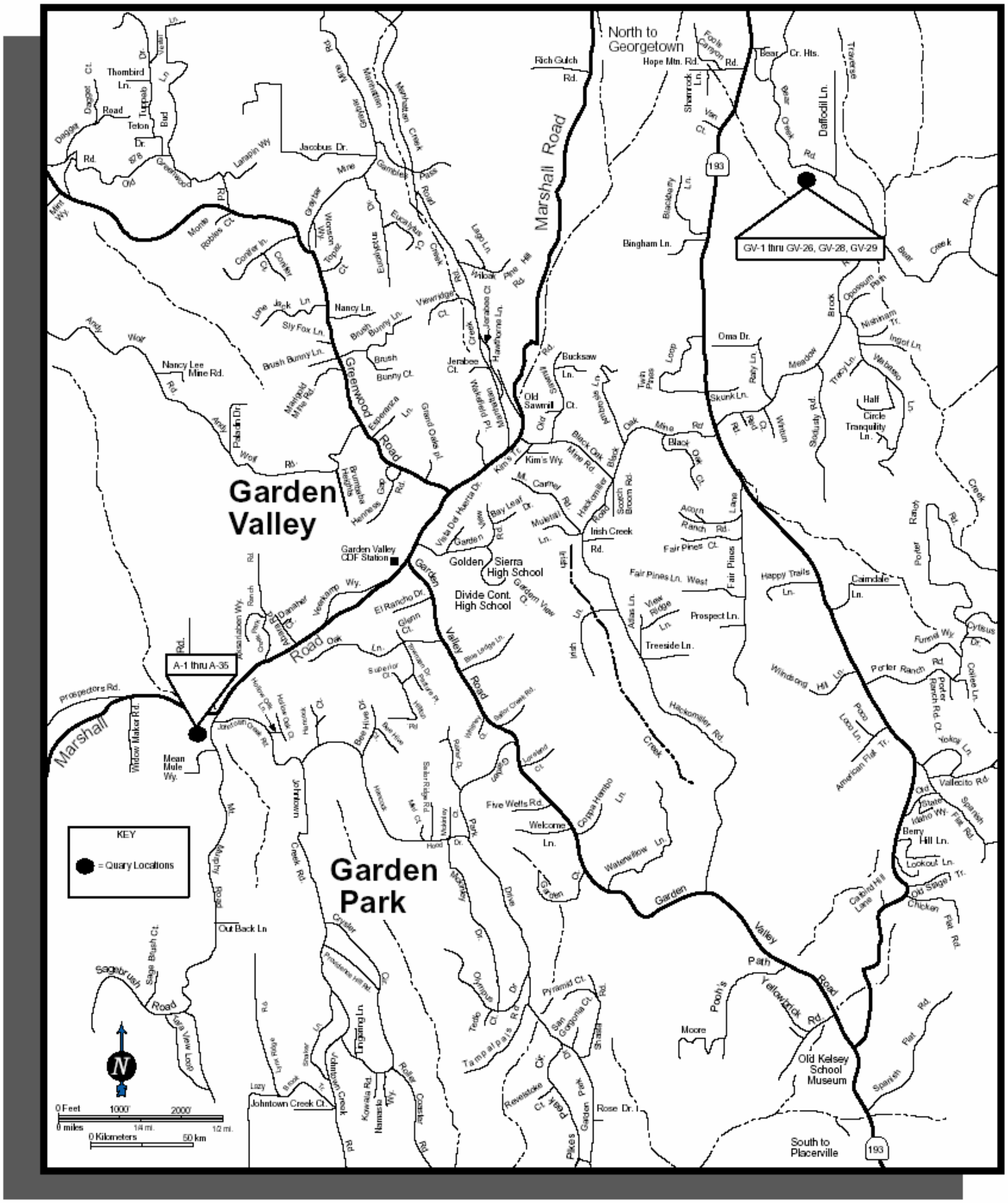
El Dorado County, California

Garden Valley Site Discovery Area

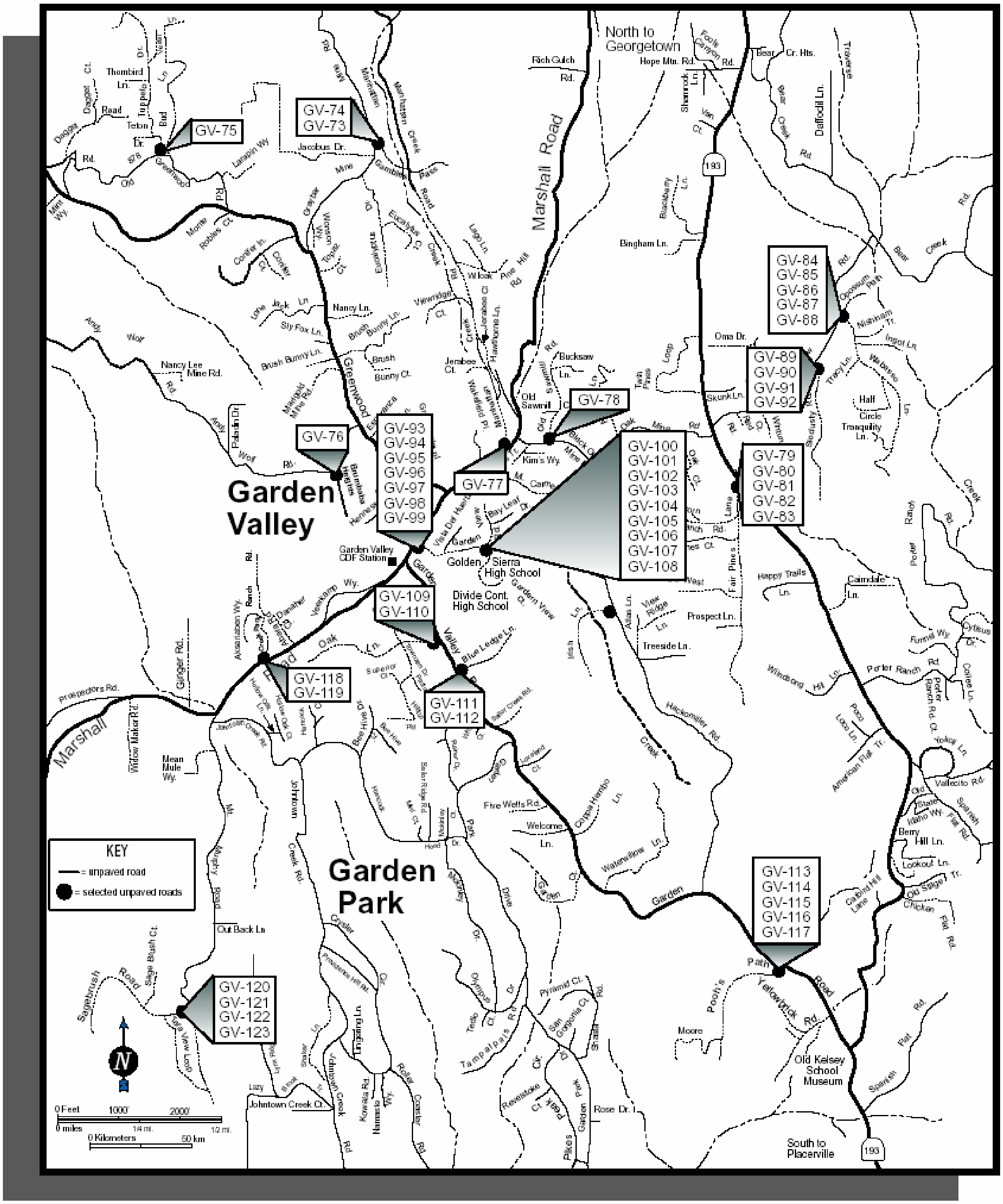


Garden Valley Site Discovery Area

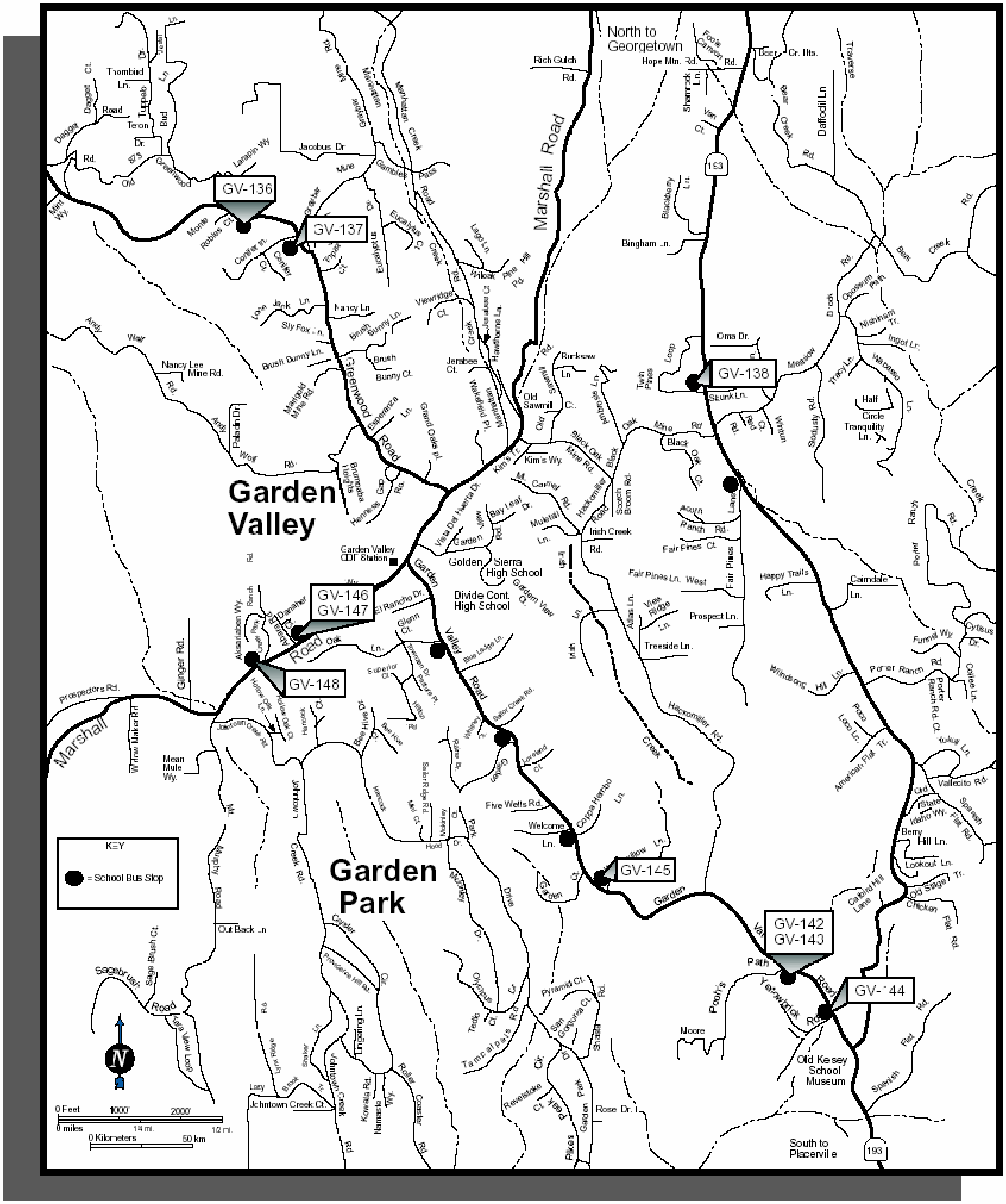
Map of Quarry Locations and Sample Numbers



Garden Valley Site Discovery Area
Map of Unpaved Roads



Garden Valley Site Discovery Area
Map of Selected School Bus Stops



TABLES

Summary of Percent Moisture

Sample #	% Moisture	Sample #	% Moisture	Sample #	% Moisture	Sample #	% Moisture
A-1	1.37	GV-01	2.50	GV-79	0.15	GV-114	0.49
A-2	1.98	GV-02	3.03	GV-80	1.10	GV-115	0.61
A-3	4.11	GV-03	3.50	GV-81	1.23	GV-116	0.39
A-4	1.50	GV-04	1.37	GV-82	1.09	GV-117	0.45
A-5	0.83	GV-05	2.53	GV-83	1.29	GV-118	0.38
A-6	0.59	GV-06	2.97	GV-84	0.56	GV-119	0.36
A-7	0.98	GV-07	4.58	GV-85	0.83	GV-120	0.62
A-8	0.59	GV-08	3.55	GV-86	0.00	GV-121	1.91
A-9	0.51	GV-09	1.65	GV-87	0.17	GV-122	0.54
A-10	0.89	GV-10	1.92	GV-88	0.51	GV-123	0.39
A-11	0.60	GV-11	1.71	GV-89	0.39	GV-124	0.38
A-12	0.71	GV-12	6.06	GV-90	0.46	GV-136	0.05
A-13	0.29	GV-13	5.86	GV-91	0.54	GV-137	1.34
A-14	1.63	GV-14	2.10	GV-92	0.62	GV-138	0.10
A-15	3.86	GV-15	1.23	GV-93	0.29	GV-139	0.25
A-16	1.79	GV-16	1.05	GV-94	0.56	GV-140	0.11
A-17	0.73	GV-17	4.58	GV-95	0.23	GV-141	1.01
A-18	0.56	GV-18	5.06	GV-96	0.29	GV-142	0.99
A-19	0.55	GV-19	1.32	GV-97	0.06	GV-143	0.54
A-20	0.47	GV-20	1.66	GV-98	0.42	GV-144	0.61
A-21	0.48	GV-21	0.57	GV-99	0.49	GV-145	0.31
A-22	1.23	GV-22	0.94	GV100	0.40	GV-146	0.63
A-23	2.17	GV-23	0.01	GV-101	0.40	GV-147	0.82
A-24	1.37	GV-24	3.16	GV-102	0.87	GV-148	0.28
A-25	0.68	GV-25	4.02	GV-103	0.59	GV-168	1.81
A-26	0.80	GV-26	7.29	GV-104	0.67	GV-169	0.85
A-27	3.22	GV-27		GV-105	0.22	GV-170	1.05
A-28	0.80	GV-28	0.86	GV-106	0.23	GV-171	2.33
A-29	1.39	GV-29	6.78	GV-107	0.23	GV-172	1.70
A-30	2.65	GV-73	0.44	GV-108	0.23	GV-173	1.88
A-31	4.64	GV-74	1.14	GV-109	0.15	GV-174	2.69
A-32	0.82	GV-75	0.61	GV-110	0.17	GV-175	1.03
A-33	1.87	GV-76	0.06	GV-111	0.36		
A-34	0.93	GV-77	1.37	GV-112	1.64		
A-35	0.35	GV-78	0.10	GV-113	0.48		

Summary of Bear Creek Quarry PLM and TEM Results

Sample #	PLM Asbestos %	Qualifier	Asbestos Type	TEM Asbestos %	Qualifier	Asbestos Type
GV-01	1.8		Chrysotile	1.7		Chrysotile
GV-02	1.5		Chrysotile	--		
GV-03(-200)	15	J	Chrysotile	4.9		Chrysotile
GV-03(+200)	4.3		Chrysotile	1.8		Chrysotile
GV-04	1.3		Chrysotile	--		
GV-05	0.5		Chrysotile	--		
GV-06(-200)	0.75	J	Chrysotile	2.5	J	Chrysotile
GV-06(+200)	0.75		Chrysotile	1.2		Chrysotile
GV-07	0.5		Chrysotile	--		
GV-08	1		Chrysotile	2.2		Chrysotile
GV-09	1.8		Chrysotile	--		
GV-10(-200)	2.8	J	Chrysotile	0.67	J	Chrysotile
GV-10(+200)	2.2		Chrysotile	2.3		Chrysotile
GV-11	2.5		Chrysotile	--		
GV-12(-200)	0.75	J	Chrysotile	1.1	J	Chrysotile
GV-12(+200)	1.3		Chrysotile	4.9		Chrysotile
GV-13	1.3		Chrysotile	--		
GV-14	0.5		Chrysotile	6.4		Chrysotile
GV-15	<0.25		Chrysotile	5.7		Chrysotile
GV-16	1.5		Chrysotile	7.3		Chrysotile
GV-17(-200)	0.5	J	Chrysotile	--		
GV-17(+200)	3.3		Chrysotile	--		
GV-18	2		Chrysotile	--		
GV-19	12		Chrysotile	6.4		Chrysotile
GV-20	0.75		Chrysotile	--		
GV-21	0.5		Chrysotile	2.5		Chrysotile
GV-22	1.3		Chrysotile	3.8	J	Chrysotile

"--" = sample not analyzed
ND = None Detected
J = Result Reported as Estimated
<0.25 = Detection Limit of Method CARB 435 PLM Analysis
<0.10 = Detection Limit of US EPA Method

Summary of Bear Creek Quarry PLM and TEM Results cont.

Sample #	PLM Asbestos %	Qualifier	Asbestos Type	TEM Asbestos %	Qualifier	Asbestos Type
GV-23(-200)	1	J	Chrysotile	2.5	J	Chrysotile
GV-23(+200)	0.5		Chrysotile	1.1		Chrysotile
GV-24	2.5		Chrysotile	--		
GV-25	<0.25		Chrysotile	--		
GV-26	1.8		Chrysotile	2.6		Chrysotile
GV-27	--		Chrysotile	--		
GV-28 (-200)	2.5	J	Chrysotile	3	J	Chrysotile
GV-28 (+200)	1.8		Chrysotile	2.5		Chrysotile
GV-29	2.2		Chrysotile	4.4	J	Chrysotile

"--" = sample not analyzed
ND = None Detected
J = Result Reported as Estimated
<0.25 = Detection Limit of Method CARB 435 PLM Analysis
<0.10 = Detection Limit of US EPA Method

Summary of Total Asbestos for Bear Creek Quarry Size Fractionated Samples

PLM

Sample #	Weight of size fraction < 200 mesh (grams)	% Asbestos in < 200 mesh fraction	Weight of size fraction > 200 mesh (grams)	% Asbestos in > 200 mesh fraction	PLM total Asbestos (%)
GV-03	37	15	906	4.3	4.72
GV-06	28	0.75	1084	0.75	0.75
GV-10	34	2.8	1094	2.2	2.22
GV-12	78	0.75	809	1.3	1.25
GV-17	22	0.5	668	3.3	3.21
GV-23	23	1	1184	0.5	0.51
GV-28	48	2.5	887	1.8	1.84

TEM

Sample #	Weight of size fraction < 200 mesh (grams)	% Asbestos in < 200 mesh fraction	Weight of size fraction > 200 mesh (grams)	% Asbestos in > 200 mesh fraction	TEM total Asbestos (%)
GV-03	37	4.9	906	1.8	1.92
GV-06	28	2.5	1084	1.2	1.23
GV-10	34	0.67	1094	2.3	2.25
GV-12	78	1.1	809	4.9	4.57
GV-17	22	--	668	--	--
GV-23	23	2.5	1184	1.1	1.13
GV-28	48	3	887	2.5	2.53

Summary of XRD Results

Sample #	Serpentine*	Magnetite	Chlorite/Smectite	Andradite
A-13	89	10	<3**	-
A-33	83	9	<5**	-
GV-06(+200)	84	10	-	4
GV-22	77	10	-	4
GV-90(+200)	79	10	-	5
GV-92	85	10	-	5

* Serpentine as Lizardite and Chrysotile

** May be present below quantification concentration

Summary of Garden Valley Aggregates PLM and TEM Results

Sample#	PLM Asbestos %	Qualifier	Asbestos Type	TEM Asbestos %	Qualifier	Asbestos Type
A-1	<0.25		Chrysotile	--		
A-2	1.3		Chrysotile	1.5		Chrysotile
A-3	1.5		Chrysotile	--		
A-4(-200)	<0.25	R	Chrysotile	1.1	J	Chrysotile
A-4(+200)	1.3		Chrysotile	0.56		Chrysotile
A-5	1.5		Chrysotile	--		
A-6(-200)	1.3	J	Chrysotile	0.59	J	Chrysotile
A-6(+200)	1.3		Chrysotile	1.1		Chrysotile
A-7	1.3		Chrysotile	--		
A-8	<0.25		Chrysotile	--		
A-9(-200)	1.8	J	Chrysotile	0.76	J	Chrysotile
				<0.1	J	Anthophylite
				<0.1	J	Tremolite
A-9(+200)	0.5		Chrysotile	0.97		Chrysotile
A-10	<0.25		Chrysotile	--		
A-11	1.3		Chrysotile	0.77		Chrysotile
				<0.1		
A-12(-200)	1.5	J	Chrysotile	--		
A-12(+200)	1.5		Chrysotile	--		
A-13	1.3		Chrysotile	1.2		Chrysotile
A-14	0.75		Chrysotile	--		
A-15	1.3		Chrysotile	--		
A-16(-200)	0.5	J	Chrysotile	0.87	J	Chrysotile
				1.7	J	Tremolite
A-16(+200)	<0.25		Chrysotile	0.74		Chrysotile
				<0.1		Tremolite
A-17	4.5		Chrysotile	--		
A-18	2.5		Chrysotile	0.8		Chrysotile

"--" = sample not analyzed
ND = None Detected
J = Result Reported as Estimated
<0.25 = Detection Limit of Method CARB 435 PLM Analysis
<0.10 = Detection Limit of US EPA Method

Summary of Garden Valley Aggregates PLM and TEM Results cont.

Sample#	PLM Asbestos %	Qualifier	Asbestos Type	TEM Asbestos %	Qualifier	Asbestos Type
A-19	1.3		Chrysotile	--		
A-20(-200)	1.3	J	Chrysotile	0.17	J	Chrysotile
				<0.1	J	Tremolite
A-20(+200)	2		Chrysotile	0.86		Chrysotile
A-21	0.75		Chrysotile	--		
A-22	2.5		Chrysotile	--		
A-23	3.3		Chrysotile	0.8		Chrysotile
A-24	1		Chrysotile	--		
A-25	1.3		Chrysotile	--		
A-26(-200)	0.25	J	Chrysotile	0.3	J	Chrysotile
A-26(+200)	2.2		Chrysotile	0.79		Chrysotile
A-27	1.3		Chrysotile	--		
A-28	0.25		Chrysotile	--		
A-29	<0.25		Chrysotile	0.48		Chrysotile
A-30	0.5		Chrysotile	--		
A-31	0.25		Chrysotile	--		
A-32(-200)	0.75		Chrysotile	1.2		Chrysotile
A-32(+200)	1.5		Chrysotile	0.8		Chrysotile
A-33	1.5		Chrysotile	2.7		Chrysotile
A-34	0.5		Chrysotile	0.76		Chrysotile
A-35	0.25		Chrysotile	0.75		Chrysotile

"--" = sample not analyzed
ND = None Detected
J = Result Reported as Estimated
<0.25 = Detection Limit of Method CARB 435 PLM Analysis
<0.10 = Detection Limit of US EPA Method

Summary of Total Asbestos for Garden Valley Aggregates Size Fractionated Samples

PLM

Sample #	% Moisture	Weight of size fraction < 200 mesh (grams)	% Asbestos in < 200 mesh fraction	Weight of size fraction > 200 mesh (grams)	% Asbestos in > 200 mesh fraction	PLM total asbestos (%)
A-4	1.50	58	0.125	1321	1.3	1.25
A-6	0.59	50	1.3	1474	1.3	1.30
A-9	0.51	91	1.8	1470	0.5	0.58
A-12	0.71	56	1.5	1482	1.5	1.50
A-16	1.79	47	0.5	1493	0.125	0.14
A-20	0.47	27	2	1447	1.8	1.80
A-26	0.80	164	0.25	1201	2.2	1.97
A-32	0.82	35	0.75	1292	1.5	1.48

TEM

Sample #	% Moisture	Weight of size fraction < 200 mesh (grams)	% Asbestos in < 200 mesh fraction	Weight of size fraction > 200 mesh (grams)	% Asbestos in > 200 mesh fraction	TEM total asbestos (%)
A-4	1.50	58	1.1	1321	0.56	0.58
A-6	0.59	50	0.59	1474	1.1	1.08
A-9	0.51	91	0.86	1470	0.97	0.96
A-12	0.71	56	--	1482	--	--
A-16	1.79	47	2.57	1493	0.79	0.84
A-20	0.47	27	0.22	1447	0.86	0.85
A-26	0.80	164	0.3	1201	0.79	0.73
A-32	0.82	35	1.2	1292	0.8	0.81

Summary of Unpaved Roads PLM and TEM Results

Sample #	PLM Asbestos %	Qualifier	Asbestos Type	TEM Asbestos %	Qualifier	Asbestos Type
GV-73	<0.25		Chrysotile	--		
GV-74	0.5		Chrysotile	--		
GV-75	<0.25		Chrysotile	--		
GV-76	0.75		Chrysotile	2.00	J	Chrysotile
GV-77	<0.25		Chrysotile	<0.1		Chrysotile
GV-78	<0.25		Chrysotile	0.91		Chrysotile
GV-79	<0.25		Chrysotile	--		
GV-80	<0.25		Chrysotile	0.11	J	Chrysotile
GV-81	<0.25		Chrysotile	--		
GV-82(-200)	2		Chrysotile	7.70	J	Chrysotile
GV-82(+200)	4		Chrysotile	3.10		Chrysotile
GV-83	<0.25		Chrysotile	--		
GV-84(-200)	2.8		Chrysotile	3.20		Chrysotile
GV-84(+200)	1.2		Chrysotile	5.50		Chrysotile
GV-85	<0.25		Chrysotile	5.30		Chrysotile
GV-86	ND		Chrysotile	--		
GV-87	<0.25	J	Chrysotile	0.84		Chrysotile
GV-88	0.5		Chrysotile	2.40	J	Chrysotile
GV-89(-200)	2		Chrysotile	--		
GV-89(+200)	1.2		Chrysotile	--		
GV-90(-200)	--			--		
GV-90(+200)	1.5		Chrysotile	2.10		Chrysotile
GV-91(-200)	1.8		Chrysotile	2.80		Chrysotile
GV-91(+200)	<0.25		Chrysotile	1.40	J	Chrysotile
GV-92	0.25		Chrysotile	1.20	J	Chrysotile
GV-93(-200)	2		Chrysotile	--		

"--" = sample not analyzed
ND = None Detected
J = Result Reported as Estimated
<0.25 = Detection Limit of Method CARB 435 PLM Analysis
<0.10 = Detection Limit of US EPA Method

Summary of Unpaved Roads PLM and TEM Results cont.

Sample #	PLM Asbestos %	Qualifier	Asbestos Type	TEM Asbestos %	Qualifier	Asbestos Type
GV-93(+200)	0.25		Chrysotile	--		
GV-94	0.5		Chrysotile	1.00	J	Chrysotile
GV-95(-200)	4		Chrysotile	--		
GV-95(+200)	<0.25		Chrysotile	--		
GV-96	0.5		Chrysotile	4.90		Chrysotile
GV-97(-200)	0.25		Chrysotile	--		
GV-97(+200)	0.75		Chrysotile	--		
GV-98	1.5		Chrysotile	1.50	J	Chrysotile
GV-99	<0.25		Chrysotile	--		
GV100	<0.25		Chrysotile	0.85	J	Chrysotile
GV-101	0.25		Chrysotile	--		
GV-102	0.5		Chrysotile	0.48	J	Chrysotile
GV-103(-200)	2.2		Chrysotile	--		
GV-103(+200)	<0.25		Chrysotile	--		
GV-104	0.25		Chrysotile	0.80	J	Chrysotile
GV-105(-200)	1.5		Chrysotile	0.13	J	Chrysotile
GV-105(+200)	<0.25	J	Chrysotile	0.58		Chrysotile
GV-106	0.5		Chrysotile	3.90	J	Chrysotile
GV-107(-200)	2.2		Chrysotile	4.00	J	Chrysotile
GV-107(+200)	<0.25		Chrysotile	1.80		Chrysotile
GV-108	1		Chrysotile	--		
GV-109	ND			--		
GV-110	0.25		Chrysotile	2.10		Chrysotile
GV-111	ND			--		
GV-112	ND			--		
GV-113(-200)	2.5		Chrysotile	5.80		Chrysotile
GV-113(+200)	0.25		Chrysotile	4.90	J	Chrysotile

"--" = sample not analyzed
ND = None Detected
J = Result Reported as Estimated
<0.25 = Detection Limit of Method CARB 435 PLM Analysis
<0.10 = Detection Limit of US EPA Method

Unpaved Roads PLM and TEM Results cont.

Sample #	PLM Asbestos %	Qualifier	Asbestos Type	TEM Asbestos %	Qualifier	Asbestos Type
GV-114	1.2		Chrysotile	--		
GV-115	0.75		Chrysotile	3.00	J	Chrysotile
GV-116(-200)	2		Chrysotile	--		Chrysotile
GV-116(+200)	0.75		Chrysotile	--		Chrysotile
GV-117(-200)	2.8		Chrysotile	4.90	J	Chrysotile
GV-117(+200)	1	J	Chrysotile	4.00		Chrysotile
GV-118	0.25		Chrysotile	0.14	J	Chrysotile
GV-119	ND			--		
GV-120(-200)	0.25		Chrysotile	--		
GV-120(+200)	<0.25		Chrysotile	--		
GV-121(-200)	<0.25		Chrysotile	--		
GV-121(+200)	<0.25		Chrysotile	--		
GV-122(-200)	1.2		Chrysotile	2.20		Chrysotile
GV-122(+200)	ND			<0.1		Chrysotile
GV-123	<0.25		Chrysotile	--		
GV-124	0.75		Chrysotile	--		

"--" = sample not analyzed
ND = None Detected
J = Result Reported as Estimated
<0.25 = Detection Limit of Method CARB 435 PLM Analysis
<0.10 = Detection Limit of US EPA Method

Summary of Total Asbestos for Unpaved Roads Size Fractionated Samples

PLM

Sample #	% Moisture	Weight of size fraction < 200 mesh (grams)	in < 200 mesh fraction	Weight of size fraction > 200 mesh (grams)	in > 200 mesh fraction	PLM total asbestos (%)
GV-82	1.09	52	2	1310	4	3.92
GV-84	0.56	126	2.8	1310	1.2	1.34
GV-89	0.39	152	2	1410	1.2	1.28
GV-90	0.46	82	--	1470	1.5	not calculated
GV-91	0.54	135	1.8	1370	0.125	0.28
GV-93	0.29	155	2	1570	0.25	0.41
GV-95	0.23	100	4	1630	0.123	0.35
GV-97	0.06	136	0.25	1490	0.75	0.71
GV-103	0.59	249	2.2	1290	0.125	0.46
GV-105	0.22	157	1.5	1650	0.125	0.24
GV-107	0.23	200	2.2	1550	0.125	0.36
GV-113	0.48	178	2.5	1720	0.25	0.46
GV-116	0.39	350	2	1190	0.75	1.03
GV-117	0.45	115	2.8	1670	1	1.12
GV-120	0.62	318	0.25	1310	0.125	0.15
GV-121	1.91	86	0.125	1430	0.125	0.13
GV-122	0.54	139	1.2	1550	0	0.10

TEM

Sample #	% Moisture	Weight of size fraction < 200 mesh (grams)	% Asbestos in < 200 mesh	Weight of size fraction > 200 mesh (grams)	% Asbestos in > 200 mesh	TEM total asbestos (%)
GV-82	1.09	52	7.70	1310	3.10	3.28
GV-84	0.56	126	3.20	1310	5.50	5.30
GV-89	0.39	152	--	1410	--	--
GV-90	0.46	82	--	1470	2.10	not calculated
GV-91	0.54	135	2.80	1370	1.40	1.53
GV-93	0.29	155	--	1570	--	--
GV-95	0.23	100	--	1630	--	--
GV-97	0.06	136	--	1490	--	--
GV-103	0.59	249	--	1290	--	--
GV-105	0.22	157	0.13	1650	0.58	0.54
GV-107	0.23	200	4.00	1550	1.80	2.05

Summary of Total Asbestos for Unpaved Roads Size Fractionated Samples cont.

TEM

Sample #	% Moisture	Weight of size fraction < 200 mesh (grams)	% Asbestos in < 200 mesh fraction	Weight of size fraction > 200 mesh (grams)	% Asbestos in > 200 mesh fraction	TEM total asbestos (%)
GV-113	0.48	178	5.80	1720	4.90	4.98
GV-116	0.39	350	--	1190	--	--
GV-117	0.45	115	4.90	1670	4.00	4.06
GV-120	0.62	318	--	1310	--	--
GV-121	1.91	86	--	1430	--	--
GV-122	0.54	139	2.20	1550	0.05	0.23

Summary of Bus Stops PLM and TEM Results

Sample #	PLM Asbestos %	Qualifier	Asbestos Type	TEM Asbestos %	Qualifier	Asbestos Type
GV-136	ND			<0.1		Chrysotile
GV-137	ND			0.12		Chrysotile
				<0.1		Actinolite
GV-138(-200)	<0.25		Chrysotile	<0.1		Chrysotile
				<0.1		Tremolite
GV-138(+200)	ND			0.13		Chrysotile
GV-139	ND			0.32		Chrysotile
GV-140	ND			<0.1		Chrysotile
GV-141(-200)	2.5		Chrysotile	<0.1		Chrysotile
GV-141(+200)	<0.25		Chrysotile	1.2		Chrysotile
GV-142(-200)	1.8		Chrysotile	5.9		Chrysotile
GV-142(+200)	1.2		Chrysotile	1.6		Chrysotile
GV-143(-200)	1.5		Chrysotile	2.4		Chrysotile
GV-143(+200)	<0.25		Chrysotile	4.3		Chrysotile
GV-144(-200)	1.5		Chrysotile	4.1		Chrysotile
GV-144(+200)	<0.25		Chrysotile	1.7		Chrysotile
GV-145(-200)	<0.25		Chrysotile	0.53		Chrysotile
GV-145(+200)	<0.25		Chrysotile	0.4		Chrysotile
GV-146(-200)	2.8		Chrysotile	1.2		Chrysotile
GV-146(+200)	<0.25		Chrysotile	1.2		Chrysotile
GV-147	0.5		Chrysotile	2.4		Chrysotile
GV-148(-200)	1.2		Chrysotile	1.8	J	Chrysotile
GV-148(+200)	0.75		Chrysotile	0.85		Chrysotile

"--" = sample not analyzed
ND = None Detected
J = Result Reported as Estimated
<0.25 = Detection Limit of Method CARB 435 PLM Analysis
<0.10 = Detection Limit of US EPA Method

Total Asbestos for School Bus Stop Size Fractionated Samples

PLM

Sample #	% Moisture	Weight of size fraction < 200 mesh (grams)	% Asbestos in < 200 mesh fraction	Weight of size fraction > 200 mesh (grams)	% Asbestos in > 200 mesh fraction	PLM total asbestos (%)
GV-138	0.10	299	0.125	1810	0	0.02
GV-141	1.01	185	2.5	1310	0.125	0.42
GV-142	0.99	80	1.8	1450	1.2	1.23
GV-143	0.54	155	1.5	1730	0.125	0.24
GV-144	0.61	142	1.5	1350	0.125	0.26
GV-145	0.31	161	0.125	1790	0.125	0.13
GV-146	0.63	72	2.8	1690	0.125	0.23
GV-148	0.28	82	1.2	1750	0.75	0.77

TEM

Sample #	% Moisture	Weight of size fraction < 200 mesh (grams)	% Asbestos in < 200 mesh fraction	Weight of size fraction > 200 mesh (grams)	% Asbestos in > 200 mesh fraction	TEM total asbestos (%)
GV-138	0.10	299	0.1	1810	0.13	0.13
GV-141	1.01	185	0.05	1310	1.2	1.06
GV-142	0.99	80	5.9	1450	1.6	1.82
GV-143	0.54	155	2.4	1730	4.3	4.14
GV-144	0.61	142	4.1	1350	1.7	1.93
GV-145	0.31	161	0.53	1790	0.4	0.41
GV-146	0.63	72	1.2	1690	1.2	1.20
GV-148	0.28	82	1.8	1750	0.85	0.89

Table 10

Summary of Marshal Road Cut PLM and TEM Results

Sample #	PLM Asbestos %	Qualifier	Asbestos Type	TEM Asbestos %	Qualifier	Asbestos Type
GV-168	0.5		Chrysotile	--		
GV-169	<0.25		Chrysotile	0.14		Chrysotile
				0.16		Actinolite/Tremolite
GV-170	0.25		Chrysotile	--		
GV-171	<0.25		Chrysotile	<0.1		Actinolite
GV-172(-200)	1		Chrysotile	--		
GV-172(+200)	<0.25		Chrysotile	--		
GV-173	<0.25		Chrysotile	<0.1		Chrysotile
GV-174(-200)	<0.25		Chrysotile	--		
GV-174(+200)	0.25		Chrysotile	--		
GV-175	0.5		Chrysotile	0.61		Chrysotile

Table 11

Summary of Total Asbestos for Marshal Road Cut Size Fractionated Samples

PLM

Sample #	% Moisture	Weight of size fraction < 200 mesh (grams)	% Asbestos in < 200 mesh fraction	Weight of size fraction > 200 mesh (grams)	% Asbestos in > 200 mesh fraction	PLM Total Asbestos (%)
GV-172	1.7	63	1	1070	0.125	0.17
GV-174	2.69	71	0.125	970	0.25	0.24

TEM

Sample #	% Moisture	Weight of size fraction < 200 mesh (grams)	% Asbestos in < 200 mesh fraction	Weight of size fraction > 200 mesh (grams)	% Asbestos in > 200 mesh fraction	TEM Total Asbestos (%)
GV-172	1.7	63	--	1070	--	not calculated
GV-174	2.69	71	--	970	--	not calculated

Table 12

PLM vs TEM at the PLM Detection Limit

Sample #	PLM % Asbestos	TEM % Asbestos
GV-15	<0.25	5.7
GV-138(-200)	<0.25	<0.1
GV-141(+200)	<0.25	1.2
GV-143(+200)	<0.25	4.3
GV-144(+200)	<0.25	1.7
GV-145(-200)	<0.25	0.53
GV-145(+200)	<0.25	0.4
GV-146(+200)	<0.25	1.2
A-4(-200)	<0.25	1.1
A-16(+200)	<0.25	0.74
A-29	<0.25	0.48
GV-169	<0.25	0.14
GV-171	<0.25	<0.1
GV-173	<0.25	<0.1
GV-77	<0.25	<0.1
GV-78	<0.25	0.91
GV-80	<0.25	0.11
GV-85	<0.25	5.3
GV-87	<0.25	0.84
GV-91(+200)	<0.25	1.4
GV100	<0.25	0.85
GV-105(+200)	<0.25	0.58
GV-107(+200)	<0.25	1.8

false negatives	17
total samples	23
% of false negatives	73.91%

Summary of GPS Locations of all Samples

Sample #	Latitude					Longitude			
A-1	N	38	50.422	*		W	120	52.646	*
A-2	N	38	50.424	*		W	120	52.634	*
A-3	N	38	50.412	*		W	120	52.663	*
A-4	N	38	50.416	*		W	120	52.648	*
A-5	N	38	50.419	*		W	120	52.642	*
A-6	N	38	50.421	*		W	120	52.632	*
A-7	N	38	50.423	*		W	120	52.621	*
A-8	N	38	50.426	*		W	120	52.608	*
A-9	N	38	50.415	*		W	120	52.605	*
A-10	N	38	50.413	*		W	120	52.612	*
A-11	N	38	50.411	*		W	120	52.622	*
A-12	N	38	50.411	*		W	120	52.628	*
A-13	N	38	50.407	*		W	120	52.641	*
A-14	N	38	50.401	*		W	120	52.655	*
A-15	N	38	50.398	*		W	120	52.663	*
A-16	N	38	50.386	*		W	120	52.658	*
A-17	N	38	50.387	*		W	120	52.647	*
A-18	N	38	50.392	*		W	120	52.628	*
A-19	N	38	50.394	*		W	120	52.62	*
A-20	N	38	50.397	*		W	120	52.612	*
A-21	N	38	50.401	*		W	120	52.6	*
A-22	N	38	50.394	*		W	120	52.596	*
A-23	N	38	50.388	*		W	120	52.601	*
A-24	N	38	50.382	*		W	120	52.616	*
A-25	N	38	50.38	*		W	120	52.622	*
A-26	N	38	50.376	*		W	120	52.632	*
A-27	N	38	50.364	*		W	120	52.625	*
A-28	N	38	50.365	*		W	120	52.622	*
A-29	N	38	50.365	*		W	120	52.621	*
A-30	N	38	50.369	*		W	120	52.613	*
A-31	N	38	50.345	*		W	120	52.613	*
A-32	*	*	*	*		*	*	*	*
A-33	*	*	*	*		*	*	*	*
A-34	*	*	*	*		*	*	*	*
A-35	*	*	*	*		*	*	*	*

* data not available

Summary of GPS Locations of all Samples cont.

Sample #	Latitude					Longitude			
GV-01	*	*	*	*		*	*	*	*
GV-02	*	*	*	*		*	*	*	*
GV-03	*	*	*	*		*	*	*	*
GV-04	N	38	52	27.07771		W	120	49	29.06771
GV-05	*	*	*	*		*	*	*	*
GV-06	*	*	*	*		*	*	*	*
GV-07	N	38	52	28.67727		W	120	49	27.62693
GV-08	N	38	52	29.70283		W	120	49	26.82187
GV-09	N	38	52	27.24137		W	120	49	26.80476
GV-10	N	38	52	29.02879		W	120	49	26.06657
GV-11	*	*	*	*		*	*	*	*
GV-12	N	38	52	26.30833		W	120	49	23.84029
GV-13	N	38	52	28.27634		W	120	49	28.27634
GV-14	N	38	52	28.27198		W	120	49	24.00113
GV-15	N	38	52	29.25131		W	120	49	21.08143
GV-16	*	*	*	*		*	*	*	*
GV-17	*	*	*	*		*	*	*	*
GV-18	N	38	52	31.35477		W	120	49	23.90463
GV-19	N	38	52	30.58602		W	120	49	24.73816
GV-20	N	38	52	30.82507		W	120	49	22.87161
GV-21	*	*	*	*		*	*	*	*
GV-22	N	38	52	33.75533		W	120	49	29.50581
GV-23	N	38	52	34.67335		W	120	49	27.93951
GV-24	*	*	*	*		*	*	*	*
GV-25	*	*	*	*		*	*	*	*
GV-26	*	*	*	*		*	*	*	*
GV-27	*	*	*	*		*	*	*	*
GV-28	*	*	*	*		*	*	*	*
GV-29	*	*	*	*		*	*	*	*
GV-73	N	38	52.589	*		W	120	51.498	*
GV-74	N	38	52.761	*		W	120	51.877	*
GV-75	N	38	52.96	*		W	120	52.853	*
GV-76	N	38	51.365	*		W	120	52.37	*
GV-77	N	38	51.856	*		W	120	51.201	*
GV-78	N	38	51.709	*		W	120	50.763	*

* data not available

Summary of GPS Locations of all Samples cont.

Sample #	Latitude					Longitude			
GV-79	N	38	51.285	*		W	120	49.802	*
GV-80	N	38	50.577	*		W	120	49.796	*
GV-81	N	38	*	*		W	120	*	*
GV-82	N	38	50.532	*		W	120	49.702	*
GV-83	N	38	50.54	*		W	120	49.704	*
GV-84	N	38	51.428	*		W	120	49.039	*
GV-85	N	38	51.703	*		W	120	49.046	*
GV-86	N	38	51.731	*		W	120	49.082	*
GV-87	N	38	51.867	*		W	120	49.182	*
GV-88	N	38	51.961	*		W	120	49.224	*
GV-89	N	38	51.723	*		W	120	49.331	*
GV-90	N	38	*	*		W	120	*	*
GV-91	N	38	*	*		W	120	*	*
GV-92	N	38	51.447	*		W	120	49.363	*
GV-93	N	38	51.063	*		W	120	51.407	*
GV-94	N	38	51.075	*		W	120	51.386	*
GV-95	N	38	51.083	*		W	120	51.372	*
GV-96	N	38	51.09	*		W	120	51.352	*
GV-97	N	38	51.096	*		W	120	51.331	*
GV-98	N	38	51.09	*		W	120	51.307	*
GV-99	N	38	51.091	*		W	120	51.287	*
GV100	N	38	51.1	*		W	120	51.127	*
GV-101	N	38	51.04	*		W	120	51.154	*
GV-102	N	38	51.041	*		W	120	51.149	*
GV-103	N	38	51.003	*		W	120	51.151	*
GV-104	N	38	50.996	*		W	120	51.155	*
GV-105	N	38	50.978	*		W	120	51.157	*
GV-106	N	38	50.956	*		W	120	51.158	*
GV-107	N	38	50.945	*		W	120	51.155	*
GV-108	N	38	*	*		W	120	*	*
GV-109	N	38	50.73	*		W	120	51.55	*
GV-110	N	38	50.768	*		W	120	51.705	*
GV-111	N	38	50.564	*		W	120	51.263	*
GV-112	N	38	50.575	*		W	120	51.235	*
GV-113	N	38	49.291	*		W	120	50.051	*

* data not available

Summary of GPS Locations of all Samples cont.

Sample #	Latitude					Longitude			
GV-114	N	38	49.287	*		W	120	50.024	*
GV-115	N	38	49.232	*		W	120	50.059	*
GV-116	N	38	49.303	*		W	120	49.937	*
GV-117	N	38	*	*		W	120	*	*
GV-118	N	38	50.643	*		W	120	52.384	*
GV-119	N	38	50.707	*		W	120	52.316	*
GV-120	N	38	*	*		W	120	*	*
GV-121	N	38	49.311	*		W	120	52.859	*
GV-122	N	38	*	*		W	120	*	*
GV-123	N	38	49.518	*		W	120	53.146	*
GV-124	N	38	*	*		W	120	*	*
GV-136	N	38	52.457	*		W	120	52.477	*
GV-137	N	38	52.3	*		W	120	52.08	*
GV-138	N	38	51.659	*		W	120	49.984	*
GV-139	N	38	51.309	*		W	120	49.798	*
GV-140	N	38	50.277	*		W	120	51.007	*
GV-141	N	38	49.953	*		W	120	50.742	*
GV-142	N	38	49.377	*		W	120	49.636	*
GV-143	N	38	49.37	*		W	120	49.629	*
GV-144	N	38	49.114	*		W	120	49.405	*
GV-145	N	38	49.67	*		W	120	50.463	*
GV-146	N	38	50.677	*		W	120	52.211	*
GV-147	N	38	*	*		W	120	*	*
GV-148	N	38	50.599	*		W	120	52.394	*
GV-168	N	38	49.654	*		W	120	53.628	*
GV-169	N	38	49.654	*		W	120	53.627	*
GV-170	N	38	*	*		W	120	*	*
GV-171	N	38	49.566	*		W	120	53.628	*
GV-172	N	38	49.564	*		W	120	53.583	*
GV-173	N	38	49.561	*		W	120	53.579	*
GV-174	N	38	49.553	*		W	120	53.576	*
GV-175	N	38	*	*		W	120	*	*

* data not available

Summary of PLM and TEM Ranges and Averages

TEM

		Whole Sample	<200 Mesh	>200 Mesh	Total Calculated Asbestos of Frationated Sample
Bus Stops	Range	<0.10 – 2.4%	<0.10 – 5.9%	0.13 – 4.3%	0.13 – 4.14%
	Average	0.59%	2.00%	1.42%	1.45%
Actinolite	Range	1 sample			
	Average	<0.1			
Tremolite	Range		1 sample		
	Average		<0.1%		
Unpaved Roads	Range	<0.10 – 5.3%	0.13 – 7.7%	<0.10 – 5.50%	0.23 – 5.30%
	Average	1.85%	3.84%	2.60%	2.75%
Road Cuts	Range	<0.10 – 0.61%			
	Average	0.27%			
Actinolite	Range	<0.1 – 0.16%			
	Average	0.11%			
Tremolite	Range	1 sample			
	Average	0.16%			
Garden Valley	Range	0.48 - 2.7%	0.17 - 1.2%	0.56 - 5.3%	0.58 - 1.08%
	Average	1.08%	0.71%	2.90%	0.84%
Anthophylite	Range		1 sample		
	Average		<0.1%		
Tremolite	Range		<0.1 - 1.7%		
	Average		0.46%		
Bear Creek	Range	1.7 - 4.4%	0.67 - 4.9%	1.1 - 4.9%	1.1 - 4.57%
	Average	4.30%	2.44%	2.30%	2.27%

PLM

		Whole Sample	<200 Mesh	>200 Mesh	Total Calculated Asbestos of Frationated Sample
Bus Stops	Range	ND – 0.5%	<0.25 – 2.8%	ND – 1.2%	0.02 – 1.23%
	Average	0.10%	1.44%	0.32%	0.41%
Unpaved Roads	Range	ND – 01.5%	ND – 4%	<0.25 – 4%	0.10 – 3.92%
	Average	0.34%	1.85%	0.69%	0.77%
Road Cuts	Range	<0.25 – 0.50%	<0.25 – 1.00%	<0.25 – 0.25%	0.17 – 0.24%
	Average	0.27%	0.56%	0.19%	0.21%
Garden Valley	Range	<0.25 - 4.5%	<0.25 – 1.8%	<0.25 – 2.2%	0.14 - 1.97%
	Average	1.20%	0.94%	1.30%	1.25%
Bear Creek	Range	<0.25 - 12%	0.5 –15%	0.5 – 4.3%	0.51 - 4.72%
	Average	2.43%	3.30%	2.00%	2.07%